Population Structure and Large Scale Cooperation in Pohang, South Korea

Jun-Hong Kim

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Reading Committee:

Darryl J. Holman, Chair

Steven M. Goodreau

Bettina Shell-Duncan

Program Authorized to Offer Degree:

Department of Anthropology

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Jun-Hong Kim

University of Washington

Abstract

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Junhong Kim

Chair of the Supervisory Committee:
Associate Professor Darryl J. Holman
Department of Anthropology

Large-scale cooperation is one of the fundamental questions in the social sciences. In order to explain cooperation beyond household members and explain the creation of public goods, the peculiarities unique to human culture must be explored. Humans uphold cultural norms and have developed sanctions for those who do not follow them, or for those who take advantage of altruistic behaviors in others. Cultural group selection theory incorporates these "moral sentiments" in explaining between-group differences of social norms and cooperativeness. With this cultural group selection theory and multilevel selection theory in the background, my dissertation is composed of three related components.

The first component uses a newly developed method to empirically test for the preferential interaction among prosocial individuals that is necessary for the evolution of altruism. The higher the level of preferential interaction, the greater the chances that altruism can

evolve and be maintained. The ERGM results revealed a significant level of assortment: prosocial individuals are favored as friends by the population overall, especially by other prosocial individuals.

Having established the existence of preferential interaction, the second component of my research considers whether the structure of individual friendship is correlated with neighborhood quality. In the language of multilevel selection, this is the issue of perspective switching. Perspective switching refers to the idea that the evolution of altruism can be described by two equivalent perspectives: broad individualism and multilevel selection theory. To see whether both perspectives provide the same description, I compared social network measures of assortment (e.g. degree) and neighborhood quality measures (e.g. average prosociality within each neighborhood). While hierarchical analysis suggests higher quality neighborhoods tended to be composed of more prosocial individuals, the high quality neighborhoods did not show more popularity of ties between prosocial individuals in the friendship network.

The third component examined the external validity of my survey instrument. I examined whether the game behavior in three types of economic games (*the ultimatum game*, *the dictator game*, and *the third party punishment game*) at the village (as a subunit of city) and individual level was explained by prosociality measures in the survey. At the individual level, prosociality predicted game behavior in the ultimatum and dictator games, but not in the third party punishment game. However, none of covariates predicted game behavior at the village level.

Although there is some heterogeneity in cooperation, the overall results suggest patterns of cooperation predicted by multilevel selection characterize this population.

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Chapter 1: Introduction: Cooperation in everyday life

1.1.Large-scale cooperation

Humans are a remarkable outlier on the spectrum of culture and cooperation. Consider, by contrast, our closest relatives, the chimpanzees. When we define culture as socially transmitted information, researchers have documented a tremendous array of between-population variation in chimpanzee behavior that cannot be explained by ecology or genetics (Whiten, 2009). However, up-to-date evidence suggests that only humans display cumulative culture, cultural norms and symbolic reinforcement of norms (Hill, 2009; Sterelny, 2009). Male chimpanzees form coalitions in social competition, in male-male intergroup conflict and perhaps in hunting (Muller and Mitani, 2005). But chimpanzees do not cooperate in other realms such as information-sharing or reproduction. The size of chimpanzee cooperative groups tends to be much smaller than those of humans. Throughout the animal kingdom, humans are a great anomaly when it comes to cooperation among non-kin, although humans are not as impressive as eusocial insects in terms of reproductive cooperation (Ofek, 2013).

Large-scale cooperation is also one of the fundamental questions in the social sciences. The framing of problems associated with cooperation differs across disciplines (e.g. "tragedy of the commons," "collective action problems"), yet they have essentially the same property and logical structure. A major trend in human behavioral sciences has been to explain cooperation in terms of egoistic incentives. Evolutionary behavioral science is no exception. The three major theories for cooperation in evolutionary behavioral science are kin selection, reciprocal altruism and mutualism. Kin selection theory explains cooperation in terms of indirect benefits to an actor. In other words, individuals who behave cooperatively towards close relatives receive benefits by spreading their genetic replicas associated with the cooperative behavior (Hamilton 1964; Maynard-Smith 1964). Proposed mechanisms for cooperation among nonrelatives are reciprocal altruism and mutualism. Under reciprocal altruism, individuals who provide benefits to reliable friends are likely to be reciprocated later (Trivers 1971). Providing a favor to others may be costly in the short term, but if repaid, the long-term benefit can outweigh the cost. Likewise, mutualism explains cooperation in that individuals in a joint endeavor are likely to earn simultaneous mutual benefits (Krebs and Davies 1993; Clutton-Brock 2009b).

While these theories can explain the bulk of cooperation in humans, large-scale cooperation in human society is still an evolutionary puzzle. We regularly interact with many people with whom we have no close relationship. We participate in elaborate divisions of labor extending beyond households. Indeed, cooperative behaviors towards acquaintances or other group members are usually not that costly to the actors, especially compared to cooperation among close relatives but, in aggregate, these low-cost forms of cooperation are quite common and, it seems, socially vital. In rare cases these group-oriented behaviors are costly. For example, individuals are sometimes willing to forego their short-term interest in favor of the group's welfare such as standing on the frontlines during war and modern-day nationalism.

Empirical evidence supports the idea that this high level of group-oriented behavior has characterized our species for millennia. The maximum stable group size in primates that can be supported by grooming and other kinds of intimate interactions seems to be about 70 to 80 individuals (Dunbar 1998). Yet archeological evidence indicates the average group size of ancestral hunter-gatherers was well above 80 individuals (Boehm 1999). The typical community size of extant hunter-gatherers and horticulturalists is around 150 individuals (Dunbar, Barrett, and Lycett 2007). In addition, many hunter-gatherer groups are characterized by guarded egalitarianism that suppresses an individual's excessive influence on group matters in favor of consensual problem solving, hence suppressing within-group variation and promoting between-group interactions (Boehm 1999). Moreover, genetic differences between early human groups (measured by F_{ST} statistics) are likely to be great enough so that selective group extinction was an important features of human evolution (Bowles 2006). To account for this tendency for large-scale cooperation in humans, we need an alternative theory: cultural group selection.

1.2.Multilevel selection theory

A variety of new developments have been made in the realm of multi-level selection theory. Nature is composed of a series of nested hierarchies and, at each level, there are cohesive forces as well as disruptive ones. When cohesive forces are stronger than disruptive forces at a specific level, cooperation works at that level (i.e. genes cooperate in genomes, cells cooperate in tissues, individuals cooperate in groups and groups cooperate in meta-groups). However, the idea that natural selection can be a potent force above individual level is still controversial.

Group selection was first mentioned by Darwin (1871) in *Descent of Man*. However, Darwin and other evolutionary thinkers (e.g. Haldane 1932; Wright, 1945;Wynne-Edwards 1962) of the early and middle 20th centuries had an incomplete understanding of the underlying mechanism. The critiques of Williams (1966), Maynard-Smith (1964) and Dawkins (1976) rendered group selection a flawed idea in the scientific community. In his book, Adaptation and

Natural Selection (1966), George Williams argued that 1) conditions under which group selection can operate to are hard to realize in nature (e.g. migration between groups was too high to maintain between-group variation) and 2) individual level explanations are almost always more parsimonious than group level explanations. Maynard-Smith (1964) argued that group selection was easily disrupted by invasion from opportunistic cheaters. However, since the reformulation of the covariance equation (i.e. the Price equation, Price 1970, 1972), the multilevel selection approach has been resurrected and given theoretical validity and supported with empirical evidence (Borrello 2005, 2010; Wilson and Wilson 2007).

The simple version of the Price equation states that the more closely a character is associated with fitness, the more rapidly it will increase by selection (Price 1970). When there are two levels (e.g. groups and individuals), the Price equation partitions the force of natural selection acting on a particular trait into “between-group” and “within-group” components that are cohesive and disruptive forces at the group level, respectively (Frank 1998; Okasha 2006; Price 1972).

In modern multilevel selection theory, the gene remains the unit of selection just as in the individualist perspective (unlike early models of group selection). However, the primary target of selection depends on population structure. In this framework, group selection is a subset of multilevel selection. When a change in gene frequency (or phenotype frequency) resulting from the “between-group” component is greater than a change from the “within-group” component, group selection is at work. Otherwise, a lower level than the group is the primary target, which is usually the case. There are some exceptions. Eusociality in some ants and bees and cooperative breeding in some vertebrates are examples of reproductive cooperation at the group level (Wilson and Hölldobler 2005). That some hymenopterans show colonial existence does not mean there is no disruptive force at the group level: some “cheater” worker bees try to reproduce parthenogenetically although it is quickly detected and suppressed by fellow workers (Wilson and Hölldobler 2005). This case exemplifies one of the implications of multilevel selection theory: The evolution of cooperation at a specific level depends on the success of policing self-regarding behaviors and resolving conflict at one level below (Michod 1999). Large-scale cooperation in humans is another example and is sometimes likened to a major transition to eusociality (Wilson and Wilson 2007).

In its modern form, group selection is a theoretically plausible mechanism and empirically verified. Examples include reduced virulence (Shanahan 1990; Frank 1996; Wade et al. 2010), female-biased sex ratio among social spiders (Colwell 1981; Wilson and Colwell 1981), foraging specialization in cofounding ant queens (Rissing et al. 1989), production of a cellulosic polymer in the wrinkly spreader strain of Pseudomonas fluorescens (Rainey and Rainey 2003), territory defense in lions (Packer and Heinsohn 1996), and in-group favoritism in humans (Richerson and Boyd 2005).

1.3.Gene-Culture Coevolution

Mechanisms for group selection in humans are different from those in other organisms. In order to properly explain cooperation beyond household members and creation of public goods, peculiarities unique to human culture must be considered and explored.

The logic of natural selection is general and abstract enough to be applied to any entity (e.g. cultural units) as long as an entity satisfies the requisite conditions: Darwin’s three postulates (i.e. variation, competition and inheritance) (Okasha 2006; Henrich 2004). Throughout this dissertation, I assume human preferences for cooperation have evolved under selection both by genetic and cultural transmission mechanisms. For either case, evolutionary logic is applicable.

Because human culture satisfies the requisite conditions of natural selection, a gene-culture coevolutionary approach is justified and is becoming increasingly influential and widely-supported (Laland and Brown 2011). Gene-culture coevolution theory is based on the idea that, just as genes are inherited from parent to offspring, cultural information is transmitted from individual to individual by social learning (Boyd and Richerson 1985; Richerson and Boyd 2005; Cavalli-Sforza and Feldman 1981). While social learning in other animals is rarely stable enough to support traditions, social learning in humans is quite reliable and gives rise to cumulative culture. Since human behavior is jointly shaped by genetics and culture, gene-culture coevolutionists argue that selection operates "two systems" of inherited information. They also argue that cultural transmission can be studied using evolutionary tools, especially using modified population genetics models. Our preferences are influenced by culture and we sometimes unconsciously follow and internalize cultural norms (Henrich and Henrich 2007; Tomasello 2009). Alternative models in the social sciences (e.g. rational actor model) ignore these peculiarities of human culture.

1.4. Cultural group selection

One implication of gene-culture coevolutionary theory is that, since transmission of cultural information can be much faster than genetic transmission, culture may establish and maintain group practices, leading to stable behavioral variation among groups. Cultural institutions may persist even when substantial environmental changes are acting on genes. With regard to cooperation, gene-culture coevolutionary theory predicts that, when cultural norms are enforced by moralistic punishment (or costly punishment) and most individuals within a group conform to and internalize those cultural norms (or conformity bias), group beneficial behaviors such as altruism can be sustained (Boyd and Richerson 1992; Richerson and Boyd 2005; Henrich and Boyd 2001; Henrich 2004). If cultural norms persistently differ among groups, and these cultural differences affect the competitive ability of groups, cultural group selection is at work (Richerson and Boyd 2005, Henrich 2004). During the replacement of non-competitive groups, a member of a losing group need not be eradicated. Members of a losing group might disperse or culturally assimilate into a successful group (Soltis, Boyd and Richerson 1995).

Since extinction and dispersion of groups is believed to characterize human evolutionary history (Bowles 2006), natural selection for “two systems” of inheritance has shaped a psychology that can reap the rewards of social life (Richerson and Boyd 2005; Henrich and Henrich 2007). Examples include a readiness to acquire cooperative norms and altruism-motivating emotions such as sympathy, shame, guilt and fairness. These “moralistic” sentiments seem to be a part of human nature, together with selfish dispositions (Bowles and Gintis 2011).

One important conclusion from the modern multilevel selection theory is that the balance between levels of selection depends on how individuals are distributed into groups (i.e. population structure). An altruistic strategy can evolve usually when it confers a benefit to higher levels of biological hierarchy (Sober and Wilson 1998; Wilson and Wilson 2007). Because the relative fitness of altruists is less than that of selfish individuals within the same group, the only way for altruism to evolve is when the productivity of the altruistic group is offset by the altruist’s disadvantage within the group (Sober and Wilson 1998; Wilson and Wilson 2007).

Gene-culture coevolutionary theory adds that, in this preferential interaction among altruists, each altruist does not need to share an altruistic gene. The phenotype can be purely cultural. Culture can provide balancing forces by spreading cultural norms that promote within-group homogeneity and provide less costly means for moralistic punishment (e.g. gossip) (Richerson and Boyd 2005). Selection above the individual level is potentially more important for humans than it is for most other organisms because of shared cultural norms. When altruistic individual preferentially interact with other altruists with the help of cultural norms, the benefits of altruism will be conferred largely to other altruists without exploitation by free-riders (Hamilton 1975; Henrich 2004; McElreath and Boyd 2007; Richerson and Boyd 2005; Bowles and Gintis 2011). Two proximate mechanisms in cultural group selection are 1) conformity bias (imitating and internalizing most prevalent cultural norms) and 2) costly punishment (disrupting behaviors are sanctioned by punishment).

1.5.The aims of this dissertation

The purpose of this dissertation research is to examine the structure of large-scale cooperation. The main body of my dissertation is composed of three related components (chapter 2-4).

The first component develops a new method to empirically test the assmumption that there is preferential interaction among prosocial individuals---something that is necessary for the evolution of altruism. The higher the level of preferential interaction, the greater the chances that altruism can evolve and be maintained (McElreath and Boyd 2007; Fletcher and Doebeli 2009). I demonstrate this by quantifying preferential interaction in a novel way: using social network analysis of friendship networks.

Having established the existence of preferential interaction, the second component of my research asks about whether the structure of individual's friendship is correlated with neighborhood quality. In the language of multilevel selection, this is the issue of perspective switching. Perspective switching refers to the idea that the evolution of altruism can be described by two equivalent perspectives: broad individualism and multilevel selection theory (Sterelny 1996; Dugatkin and Reeve 1994; Kerr and Godfrey-Smith 2002). From a prosocial individual's perspective, she finds herself mostly with other prosocial friends. From population's perspective, social group structure may be a proximate mechanism to preferential interaction. To see whether social group structure is a main mechanism of assortative interaction, I compare social network measures of assortment (e.g. degree) and neighborhood quality measures (e.g. average prosociality within each neighborhood).

The third component serves to examine the external validity of my survey instrument and to explore whether experimental games can explain within-group variation of prosociality. Since the measure of prosociality in the first research component was a survey, I compare self-reported prosociality to actual behavior in three types of economic games (the ultimatum game, the dictator game, and the third party punishment game). Experimental games can be used to make standardized measurements of preferences. For example, I look at whether the preference for costly punishment in the third party punishment game is positively correlated with individual prosociality and neighborhood quality.

1.6. Field site

In a sense, my dissertation research falls outside the mold of tradition in behavioral ecology: hunter-gatherers vs. modern city and individualist perspective vs. multilevel selection approach. However, as David Sloan Wilson (2011) asserts, the ecology of a modern city is the product of biological and cultural evolution to the same degree as hunter-gatherer society. Thus, it makes perfect sense to examine cooperation in a modern city from evolutionary perspective.

I chose Pohang, South Korea as a field site for three reasons. First, because of my personal connections, it was easy to obtain permission from school representatives and project logistics. Second, the social processes in Korea that contribute the construction of neighborhood clusters are different from those in Western countries where empirical studies of multilevel selection and social capital usually take place. Lastly, South Korea is racially and ethnically highly homogeneous. In addition, competition for prestigious jobs and higher education is very intense in South Korea which may have a detrimental effect on adolescences' social capital. In a 2009 International Civic and Citizenship Education Survey (ICCS) report, Korea is ranked the lowest (among 38 countries) in the scale of student's trust in civic institutions (such as national government, political parties, schools and people in general) and participation in civic activities (such as human right organization and environmental organization) (Schulz et al. 2010).

Pohang is famous for its steel industry (the largest steel company, POSCO, in South Korea is there) and its economy depends on the steel industry and shipbuilding. One of top engineering university in South Korea is located in Pohang: Pohang University of Science and Technology. Its population is about 5 hundred thousand.

1.7. Fieldwork Procedure

○ 1st visit (September 2010): Pilot study

During this visit, I tested the feasibility of study design by implementing survey on one school (*N*=450) and conducted third party punishment games on a selected sample (*N*= 27).

○ 2nd visit (December 2011): Establishing field site

Main purpose for this short visit was to ask for cooperation from school representatives, since their permission and cooperation would be crucial to the success of the fieldwork. I visited nine schools and asked for permission, resulting in eight acceptances and one denial.

○ 3rd visit (March to June, 2012): Main fieldwork

During the first five weeks of the main fieldwork, I implemented surveys in eight high schools (*N*=2,524). Following some preliminary data analysis, I recruited subsamples from the survey participants and administered focus group interview (*N*=40) and economic game experiments (*N*=500).

Chapter 2: Using network methods to test preferential interaction among Korean high school students

2.1. Introduction

Unless altruistic behavior is inexpensive (i.e. weak altruism), preferential interaction is required for the evolution and maintenance of altruism (McElreath and Boyd, 2007; Kerr and Godfrey-Smith, 2002). However, methods to quantify this preferential interaction have not been fully developed. Previous work has demonstrated preferential interaction by the presence of a structured population where a group structure is assumed to entail preferential interaction (e.g. Wilson and Dugatkin, 1997) or partner choice (e.g. Noe and Hammerstein, 1994). In this paper, we introduce a new method to measure preferential interaction using social network analysis. We use the method to explore whether friendship networks in one high school in South Korea show characteristics of preferential interaction.

We employ a survey instrument that is similar to the “Developmental Assets Profile (DAP)” used by Wilson et al. (2009), augmented by friendship network and demographic questions. However, unlike Wilson et al. (2009), the focus of this paper is preferential interaction among prosocial individuals rather than the influence of neighborhood property on individuals. In addition, this study was conducted in a different cultural setting, a high school in Pohang, South Korea. Before unfolding our position in detail, we summarize the findings of Wilson et al. (2009) study.

The Binghamton Neighborhood Project of Wilson et al. (2009) gave an intriguing empirical test of some predictions that arise from multilevel selection theory. They indirectly tested preferential interaction by population structure and analyzed contributing factors to individual prosociality. They found that individual prosociality is highly correlated with an individual's assessment of social support as well as with other students' average assessment of social support within the same neighborhood. They interpreted the high level of correlation between individual prosociality and neighborhood average of social support (i.e. the average of social support across individuals within same census block group; henceforth, neighborhood quality) as a non-random distribution of prosocial individuals (i.e. preferential interaction). They further supported their argument using hierarchical analysis of individual prosociality where a group-level neighborhood quality variable was included in second-level predictors along with individual's assessment of social support from six sources (family, general, school, religion, extracurricular activities and neighborhood) in first-level predictors. All group-level and individual-level predictors except median income were statistically significant, suggesting that neighborhood quality at the group-level contributes to a student's prosociality.

2.1.1. The evolution of altruism in human society

In evolutionary science, altruism is defined as a behavior that is beneficial to the recipient at a cost to the actor in terms of fitness (Hamilton, 1964; Kerr et al., 2004). Altruism is difficult to evolve through normal natural selection because only altruists bear fitness costs, while selfish individuals accrue fitness benefits. In order for altruism to evolve, there must be some constraints such as preferential interaction among altruists (McElreath & Boyd, 2007; Fletcher & Doebeli, 2008) and punishment of norm avoiders (Bowles and Gintis, 2011; Peterson and Boyd, 2005).

We use the less constrained term prosociality instead of altruism, because cooperation can be achieved through highly costly altruism as well as low-cost prosocial behavior. Low-cost prosocial behaviors have an important function in the creation of public goods. For example, individuals may invest a small amount of time participating in voting or in recycling programs, where the sum of individual efforts is quite valuable at the group level.

With some notable exceptions, most costly forms of altruism in humans can be explained by kin selection (Henrich & Henrich, 2007; Alexander, 1979). Kin bias is prevalent in alliance formation, exchange of labor service, food sharing, wealth inheritance and childcare (Barrett, Dunbar, and Lycett, 2002). For example, Henrich and Henrich (2007) asked Chaldeans in Detroit, MI, about the list of people they can rely on in times of critical needs (e.g. help when sick, medical bills, funeral and business loans). Average coefficients of relatedness in the list ranged from between 0.23 and 0.4.

On the other hand, most low-cost forms of cooperation, where the degree of self-sacrifice is typically negligible, can be explained by reciprocity, reputation (i.e. indirect reciprocity) or cultural group selection. In small-scale societies, reputation and other indirect mechanisms (e.g. costly signaling) are mainly responsible for the creation of public goods (Henrich & Henrich, 2007). By contrast, in large-scale societies, since individuals cannot keep track of past interactions and reputations, the internalization of cultural norms and punishment of norm-violators seems to be a primary mechanism in the promotion of preferential interaction among prosocial individuals or, alternatively, keeping cheaters in check (Henrich & Henrich, 2007; Bowles & Gintis, 2011). This does not mean reputation and other signaling mechanisms are not working in large scale societies; there must be a synergistic interaction between cultural group selection and reputation building. And, even in small-scale hunter-gatherers, long-term directional flow of resources from skilled individuals to needy families cannot be understood solely by reputational mechanisms or “tolerated theft” (Hill et al., 2009).

2.1.2. Multilevel selection and population structure

Group selection in human societies has often been treated as an exceptional case in the group selection debates, and regarded as less troublesome than group selection in non-human animals (Haldane, 1932; Sober & Wilson, 1998; Richerson & Boyd, 2005). Even George Williams, who was instrumental in debunking the biological group selection arguments of Wynne-Edwards (1962), acknowledged the existence of “group-related adaptation” in humans (1966:93). Only in the last couple of decades has rigorous empirical research on cultural group selection in humans been undertaken (e.g. Soltis et al., 1995; Henrich & Henrich, 2007; Mathew & Boyd, 2011). The analysis and interpretation of empirical investigations has been hampered by the variety of structures a population can have. If population structure yields groups with identifiable and distinct boundaries and cohesiveness among group members is high, then as the Price equation (1970, 1972) has shown, partitioning total fitness change into within-group and between-group components is relatively straightforward. When a population is structured as isolated or semi-isolated subgroups where the frequency of altruists varies among groups, the evolution of altruism can be described in multilevel terms. In other words, the causal relationship between the property of group and group fitness is relatively easy to establish (Godfrey-Smith, 2008; Maynard-Smith, 2002). Yet, this simple population structure is very rare in nature.

The other extreme is neighborhood-structure where group boundaries can be fluid and group membership can differ among individuals. Each individual is the center of its own focal group. Essentially, there are as many groups as there are individuals. While discrete (or semi-isolated) and cohesive groups can be described and analyzed using a multilevel selection framework, the neighborhood-structured cases cannot. When there are distinct boundaries one way to measure group productivity is as a function of the frequency of altruist and we can assign output to different types of individuals (i.e. altruists and cheaters). However, when a boundary is fluid and personal, an effect of one individual's behavior can be widely distributed across neighborhoods (i.e. multiple groups).

An example of neighborhood-structure would be a friendship network. If A befriends B and B befriends C and if we assign A and C to different groups, what group does B belong to? In this case, the only possible formal description is a mathematically-equivalent contextual approach that assigns fitness to a lower level (e.g. individual) and treats the group as an environment of individuals (e.g. friends of the focal individual) (Kerr & Godfrey-Smith, 2002; Dugatkin & Reeve, 1994; Sterelny, 1996). Although the formal description is problematic, it does not mean that higher levels of selection do not exist in neighborhood structured populations. Wilson and colleagues have used computer simulations to show that the neighborhood-structured case can yield results similar to the group-structured case (Wilson, 1980; Mitteldorf & Wilson, 2000).

Real population structure should lie somewhere on the spectrum between tight, cohesive group-structured population and fuzzy, diffused neighbor-structured population. Then, friendships in urban neighborhoods belongs to the latter (not the former) because, in many urban settings, boundaries among neighborhoods are not well defined. Further, each individual's primary social interactions may not take place within the same neighborhood. People find friends in their work place or college and mates from different cities, or even different nations. If an individual's social network is structured this way, the division of the meta-population by census group or administrative unit is arbitrary. Real urban neighborhoods probably demonstrate characteristics intermediate between idealized social groups and the figurative model neighborhood of Godfrey-Smith (2008). The difficulty of applying the Price equation to the neighborhood structured case doesn't mean that multilevel selection or cultural group selection in the modern world is meaningless.

We take a different approach to investigating multilevel selection. Rather than trying to measure group and individual fitnesses from the first stage with the assumption that there is a clear-cut group structure, we test for one of the necessary conditions under which multilevel selection exists. Specifically, we test for the existence of preferential interaction within a network of individuals that are potentially heterogenous in their prosocial tendencies.

2.1.3. Preferential Interaction

Regardless of group structure, preferential interaction among altruistic individuals is a necessary condition for altruism to evolve (Hamilton, 1975; McElreath & Boyd, 2007; Fletcher & Doebeli, 2008). When other-regarding behavior is not costly to actors, positive association is not required for prosociality to evolve (e.g. mutualistic interaction and weak altruism). However, when the cost of altruism is greater (i.e. the fitness benefit to the recipient is greater than the cost to the actor, $b \gg c$), the degree of positive assortment must be greater for altruism to proliferate (Bowles & Gintis, 2011). Cooperation evolves when the benefits of altruistic behavior preferentially flows toward the actor or other altruistic individuals without exploitation by the self-interested. For example, if virtually every individual plays the defector strategy in an iterated prisoner's dilemma game, the cooperative strategy can invade this population only through clustering or kinship (Axelrod & Hamilton, 1981). Therefore, the success of the altruistic strategy depends upon population structure—that is, how the individuals are distributed into groups. In this preferential interaction among altruists, each altruist need not share an “altruist gene.” Rather, it can be a cultural phenotype (Richerson & Boyd, 2005). Altruism can evolve as long as altruists associate positively with other altruists.

The importance of population structure can be illustrated with a thought experiment. Consider the extreme case of preferential interaction in which groups contain all altruists or all selfish individuals. It is not difficult to imagine that profound differences in group productivity exist among these groups. For more intermediate (and realistic) cases, the degree of preferential association will show a positive correlation with group productivity in each group.

Wilson and colleagues’ Binghamton neighborhood study (2009) has demonstrated significant between-neighborhood variation in prosociality and social support. However, their study does not tackle the question of how interactions between individuals would lead to neighborhood level differences. By using social network analysis, this study reveals the bottom-up process of how individual interactions might aggregate to the group-level. Therefore, this study provides a novel method for testing a fundamental principle of multilevel selection.

2.2. Materials and Methods

2.2.1. Subjects

The field research was conducted in Pohang city, South Korea. Pohang is well known for its steel industry and shipbuilding. Social processes in Korea that contribute to the construction of neighborhood clusters differ somewhat from those in Western countries where empirical studies of multilevel selection usually take place. First, South Korea is racially and ethnically highly homogeneous. In addition, competition for prestigious jobs and higher education is very intense in South Korea, which may have a detrimental effect on adolescents' cooperation and concern for others. In a 2009 International Civic and Citizenship Education Survey (ICCS) report, Korea is ranked the lowest (among 38 countries) in the scale of student's trust in civic institutions (such as national government, political parties, schools and people in general) and participation in civic activities (such as human right organizations and environmental organizations) (Schulz et al., 2010).

We conducted a web-based survey for 1st and 2nd grade high school students (these correspond to the 10th and 11th grades in the US) in one high school in Pohang in 2010. The response rate was 83% (462 out of 556). High school students were used as the target population because survey response rate among high school students tends to be higher than that of adults (Converse & Stanley, 1986), and a high response rate is required for this type of social network analysis (Wasserman & Faust, 1994). Among 462 participants, 55 were excluded for a failure to answer more than 5 questions, or identical score for all items (e.g. 1-1-1-1) or failure to provide demographic information. The social network analyses were conducted for a single grade (N=238).

The survey is a modified version of the survey used in Wilson et al.'s (2009) study from Binghamton Neighborhood Project. We included additional demographic and friendship network questions (Box 1). Individual prosociality questions (8 questions) measured a respondent's willingness to maintain a cooperative relationship with other people (e.g. "I am helping to make my community a better place."). Answers were given on a five-point Likert scale (1=not at all to 5=always). In addition to individual prosociality questions, participants were asked to list their seven closest friends with unique identifiers that included names, addresses and home rooms.

BOX 1 Survey question

Annual Income of your family (if both parents earns money, sum both incomes):
1. Less than $25,000
2. More than $25,000 but less than $40,000
3. More than $40,000 but less than $60,000
4. More than $60,000 but less than $100,000
5. More than $100,000
6. Unable to answer

Father's education level:
1. Elementary school dropout 2. Elementary school graduate 3. Middle school dropout 4. Middle school graduate 5. High school dropout 6. High school graduate 7. College dropout 8. College graduate 5. Postgraduate

Prosociality
1. "I think it is important to help other people."
2. "I resolve conflicts without anyone getting hurt."
3. "I tell the truth even when it is not easy."
4. "I am helping to make my community a better place."
5. "I am trying to help solve social problems."
6. "I am developing respect for other people."
7. "I am sensitive to the needs and feelings of others."
8. "I am serving others in my community"

Social Network
For your seven closest friends, provide a full name, grade, class and the neighborhood in which he or she lives.

2.2.2. Statistical methods

For each subject, five variables were collected: sex, household income, father's education level, individual prosociality, and a list of friends. Individual prosociality scores were calculated by taking the average score for 8 prosociality questions (Box 1). Friendship networks were constructed from the friendship information. All edges were treated as directed. Directed networks treat reciprocating nominations between two individuals as two separate edges.

Individual (or “node,” in network parlance) attributes include four variables: measures of prosociality, father’s education level, household income and sex.

Our expectations are that preferential interaction (“homophily” in network parlance) will occur at higher rates among prosocial individuals, so that prosocial individuals have more interactions with other prosocial individuals than selfish individuals do with other selfish individuals. More precisely, if we assume only two types are present in the group (more prosocial and less prosocial individuals; see Table 1), then when preferential interaction occurs, ties will be more frequent between more pairs of prosocial individuals (i.e. the type 1 ties) than other types of ties are (i.e. types 2, 3 and 4). We can also extend this to a continuous prosociality variable. For example, when preferential interaction occurs, we expect a pair of actors to be more likely to have a tie, the more prosocial they both are.

Three kinds of social network analysis were conducted. First, we considered centrality measures and their association with the node attributes (individual prosociality and household income, father’s education level). Centrality measures capture the extent to which an individual occupies a “central” position in the network, defined in multiple ways. There are four widely used centrality measures: degree, closeness, betweenness, and eigenvector centrality (Freeman 1977, 1979). Degree is the simplest measure and is defined as the number of individuals who have a connection with a focal node by treating alters (i.e. friends of focal individual) equally. On the other hand, eigenvector centrality gives weight to a connection according to the centrality of the focal individual’s friends. Simply, eigenvector centrality declares that central nodes are those with many central neighbors. We did not use the measures of closeness and betweenness because they measure the influence of a node over information or resource flow and thus cannot address a dyadic preferential interaction.

Table 1. Types of ties when two types of individuals are present. Edges are directed and from rows to column. For example, tie type 2 is the ties from more prosocial individuals to less prosocial ones. When preferential interaction occurs, the number of tie type 1 should be more frequent than other types of ties.

Edges from rows to column	More prosocial individuals	Less prosocial individuals
More prosocial individuals	Type 1 tie	Type 2 tie
Less prosocial individuals	Type 3 tie	Type 4 tie

Second, a mixing matrix (i.e. adjacency matrix) was used to assess preferential interaction among more prosocial individuals. A 2×2 mixing matrix gives the density of edges between nodes with different characteristics, in this case different levels of prosociality (Wasserman & Faust, 1994) (essentially, it is Table 1 with numbers for each of the four tie types filled in.) The mixing matrix provides a simple display of the frequencies of friendship types. We converted the individual prosociality variable to a new dichotomous variable at the median value of individual prosociality (= 3). We then subdivided each group into two subgroups, more prosocial and less prosocial individuals, with similar number of individuals (115 vs. 123) for each subgroup. Lastly, we used a chi-square test for preferential interaction. Expected numbers of edges are calculated by the product of three numbers: 1) proportion of subgroup where the friendship is named from (in network parlance, ego), 2) proportion of subgroup where friendship is directed to (in network parlance, alter) and 3) total number of friendship (or edges). For example, the expected number of edges among less prosocial individuals is 222.5

(=0.517×0.517×833). Since the cutoff can be made at any value, the mixing matrix does not provide robust statistics for continuous variables such as prosocialty score in our study. Additionally, the mixing matrix does not properly account for the non-independence resulting from many individuals having multiple friendships. Even so, it provides a quick and approximate overview of social relationships.

Finally, exponential random graph models (ERGMs, Frank & Strauss, 1986; Hunter et al., 2008; Robins et al., 2009; Snijders et al., 2006; Wasserman and Pattison, 1996) were used to identify variables that predict ties between individuals in the friendship network; ERGMs are a preferred alternative to an analysis of correlations because the model can control for multiple predictors while also controlling for the non-independence inherent in network structures, and yields similar interpretations. Potential terms in an ERGM model include functions of node and edge covariates (such as counts of friendships by prosiciality scores of the actors in them) or structural elements, such as counts of triangles or other forms of clustering. (For a list of ERGM terms, see: http://svitsrv25.epfl.ch/R-doc/library/ergm/html/ergm-terms.html.)

Two kinds of ERGM model were used to compare preferential interaction by prosociality to preferential interaction by other node attributes (i.e. fathered education and household income). Common terms in both models (explained in turn below) include counts of edges, sex-homophilous edges and nodes with zero out-tie. Since we collected a maximum of seven friendship nominations, the models has constraint that no node can have more than seven out-ties. The constraint limits mean that during both model estimation and simulation, the space of possible networks considered only includes those in which all nodes have seven or fewer out-ties. This constraint thus truncates the distribution of numbers of friendships and makes all of the other parameters interpretable.

The interpretation of the coefficient on the count of edges is similar to an intercept in multivariate analysis. When all other coefficients in the model are zero, this term indicates the log-odds of a tie between dyads. The sex-homophily term produces a coefficient that is interpreted as an increase in log-odds of tie between dyads if the two actors are of the same sex. If dyads are of different sex, then there is no increase. For example, if the coefficients of edge and nodematch("sex") term are -7 and 3 respectively, the log odds of tie between dyad is -4 assuming all other covariates are zero. A term for nodes with zero out-tie was included to estimate a specific propensity to be a "loner" – that is, to nominate no friends, since these were found to be highly over-represented in the data relative to any reasonable null model (51 out of 238 nodes). This is a fairly typical pattern for adolescent friendship networks, and may include both true "loners" and those who simply didn't bother to fill out the list of friends in the survey or who nominated others who did not participated in the survey.

ERGM model 1: To motivate the additional terms in this model, we refer to the classification of ties according to the property of node and alter presented in Table 1. Previously, we defined preferential interaction in terms of the relative preponderance of type 1 ties. However, more numerous ties of type 1 can be attributed to two things: popularity and homophily. Popularity means prosocial individuals tend to have more incoming and outgoing edges (ties) than others do. Homophily means people with similar level of prosociality tend to associate with each other. Table 2 shows the nature of the coefficients in a model containing popularity and homophily terms based on a dichotomized prosociality metric. The log-odds of a tie includes θ_1 for all actor pairs, regardless of their prosociality; θ_2.and θ_3 reflect the addition to the log-odds for ties coming out from and going in to prosocial individuals, respectively; θ_4

reflects the addition for ties that are homophilous on prosociality. In our model, however, we are able to extend the analysis beyond a simple dichotomization of prosociality and use the full prosociality score. In this case, θ_2 and θ_3 reflect increases in log-odds for each unit increase in the prosociality score for the relevant actor. For this model, the θ_4 parameter is the effect of the absolute difference in the prosociliaty score of the two nodes, such that a negative coefficient means that nodes that are more similar in score are more likely to have a relationship.

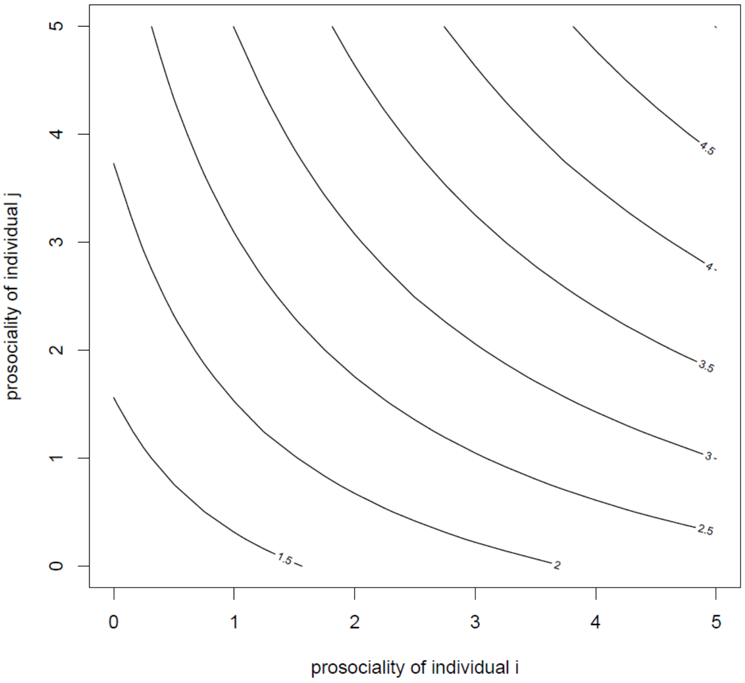
Table 2. The parameterization of ERGM model 1

Edges from rows to column	More prosocial individuals	Less prosocial individuals
More prosocial individuals	$\theta_1 + \theta_2 + \theta_3 + \theta_4$	$\theta_1 + \theta_2$
Less prosocial individuals	$\theta_1 + \theta_3$	$\theta_1 + \theta_4$

Parameters: θ_1 is the default level of friendship without popularity and homophily; θ_2 is the effect of prosociality on outgoing ties (positive means individuals with higher prosociality have more numerous outgoing edges); θ_3 is the effect of prosociality on incoming edges; θ_4 is the effect of homophily (association with others exhibiting a similar level of prosociality).

ERGM model 2: While the first ERGM model can separate out three independent effect of prosociality on friendship, the disadvantage is that first model does not test whether type 1 ties are uniquely more frequent than others. In order to test preferential interaction with a single value, we define a new measure for each pair of actors, the square root of the product of their two prosociality scores (Figure 1). This measure increases with increasing prosociality for either actor, but the product ensures that it increases most when both actors are highly prosocial. Thus, it emphasizes homophily specifically at the highly prosocial end of the scale. We take the square root to scale the metric more like our other measures (i.e. from 1 to 5).

Figure 1. Contour plot for the matrix for EGRM model 2. Each cell in the new matrix is the square root of product of dyad's prosociality. The number in x and y axis correspond to prosociality scores of dyad (i, j). The labels at the right end of each contour line are the square root of products of prosociality of dyads.



Both models were checked for convergence and goodness of fit between simulated and observed network (see Appendix B).

2.3. Results

Descriptive statistics for prosociality are given in Table 3. Average prosociality score and its standard deviation in male participants are greater than those in female participants.

Table 3. Mean scores, standard deviation and ranges on the prosociality

Prosociality	Mean	S.E.	Range
All population (N=238)	3.093	0.603	(1.5,5)
Male (N=101)	3.14	0.666	(1.5,5)
Female (N=137)	3.059	0.552	(1.75,4.75)

The friendship network (Figure 2) contains 238 individuals and 833 directed edges representing a friendship nomination. There were 9 isolates, meaning these individuals did not name any friends and were not listed by other participants as a friend.

The analysis of correlation between centrality measures and node attributes shows a positive and significant association (r= 0.165) between individual prosociality and degree while all the other associations were non-significant (see correlation coefficients and confidence intervals in Table 4).

Figure 2. Directed friendship network in a South Korean high school: Circles and arrows show individuals and friendship, respectively. The diameter of circle shows relative level of individual prosociality. The network analysis reveals preferential friendship by individual prosociality.

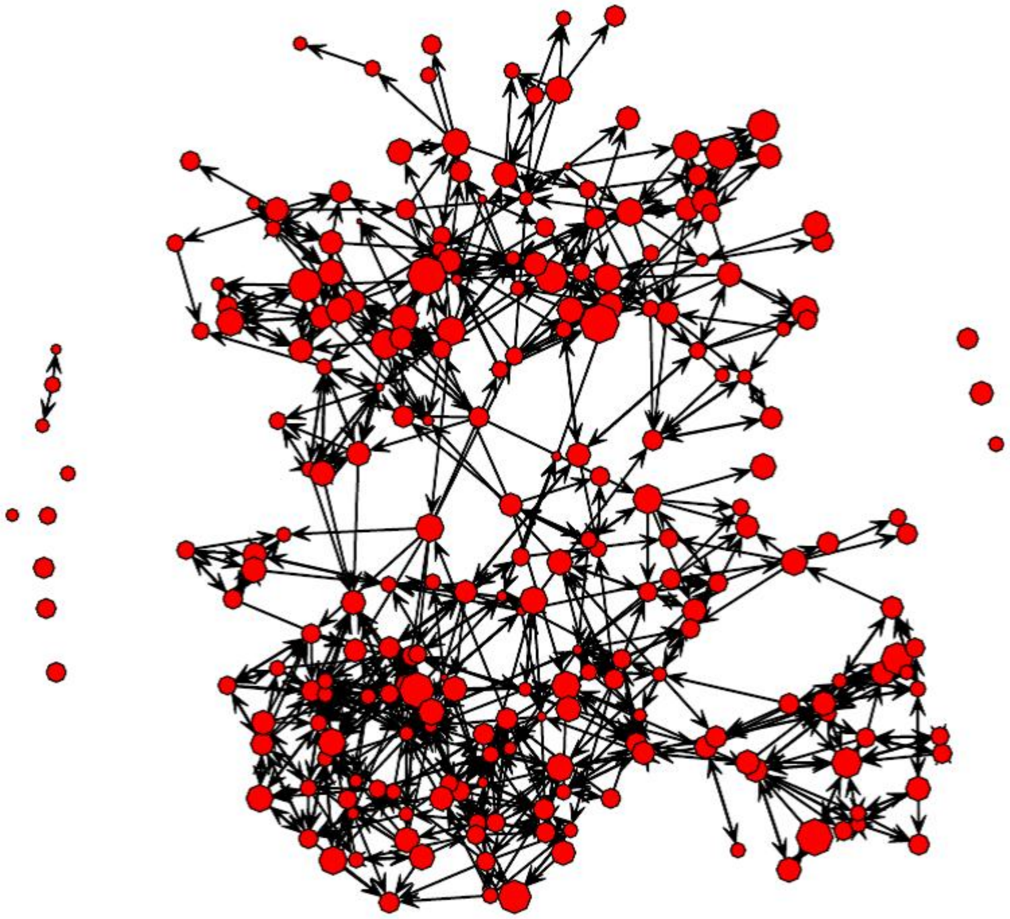


Table 4. Pearson's *r* between centrality measures and node attributes (95% confidence interval)

	Individual prosociality	Father's education	Income of household
Degree	0.165* (0.039, 0.286)	−0.084 (−0.209, 0.044)	−0.053 (−0.179, 0.074)
Eigenvector centrality	−0.005 (−0.132, 0.122)	−0.084 (−0.209, 0.043)	−0.032 (−0.159, 0.095)

* Significant at $p < 0.1$

Table 5. Mixing matrix between different levels of prosociality. Numbers outside and within parentheses are observed and expected numbers of friendship, respectively. Expected numbers of edges are the product of three numbers: 1) proportion of subgroup where the friendship is named from, 2) proportion of subgroup where friendship is directed to, and 3) total number of friendship (833). For example, the expected number of friendship among more prosocial individuals is 194.5 (=0.483×0.483×833).

	More prosocial individuals (N=115)	Less prosocial individuals (N=123)
More prosocial individuals (N=115)	216 (194.5)	222 (208)
Less prosocial individuals (N=123)	199 (208)	196 (222.5)

The mixing matrix is given in Table 5. If there is no assortative interaction between individuals (i.e. a random friendship without regard to prosociality), the four cells in the mixing matrix should have similar counts to the expected (i.e. the expected counts according to the proportion of each subgroup). However, friendship between pairs of more prosocial individuals and friendship from more prosocial individuals towards less prosocial individuals are more frequent than the expected counts. The chi-square goodness-of-fit test ($\chi 2 = 6.865$, 1 d.f., p-value < 0.01) suggests that mixing occurs preferentially.

The ERGM results confirmed the preferential interaction. In model 1 (Table 6a), the only significant and positive term among preferential interaction terms is nodeocov (prosociality) term. If the mixing matrix is a correct description, this means the high frequency of type 1 ties is due to prosocial individuals having more frequent outgoing ties. As would be expected, homophily by sex is the best predictor in the model. If person A and B have prosociality scores of 4 and 2, respectively, controlling for sex, the odds of a tie from person A to B is 1.73 ($= \exp(4\times0.137)$) and the odds of tie from B to A is 1.32 ($= \exp(2\times0.137)$), as long as both actors have at least one outgoing tie. In other words, controlling for sex and assuming at least one outgoing tie, a tie from A to B is 1.73 times as likely than if both had prosociality scores of zero. If one has no other ties, then the odds of tie from A to B is 0.096 ($= \exp(4\times0.137-1\times2.888)$) because the number of nodes in the network with out-degree zero will decline by 1. If both have no other ties, the odds of a tie from A to B is 0.005 ($= \exp(4\times0.137-2\times2.888)$) because the number of nodes in the network with out-degree zero will decline by 2. The general interpretation of model 2 (Table 6b) is the same as model 1: the only significant and positive term among preferential interaction terms is the edgecov (prosociality) term. According to model

2, controlling for sex, the odds of a tie between the same dyad is 2.208 (=exp(0.28×(4×2)½)) for both directions, as long as both actors have at least one outgoing tie.

Table 6. ERGM estimates

a) Model 1

ERGM terms	Estimate	Std. Error	*p*-value
Edges	-7.017	2.066	<0.001***
Sex (*nodematch*)	3.574	0.389	<0.001***
Prosociality (*nodeicov*)	0.144	0.141	0.3
Prosociality (*nodeocov*)	0.137	0.082	0.095*
Prosociality (*absdiff*)	0.098	0.077	0.205
Household Income (*nodeicov*)	0.003	0.027	0.892
Household Income (*nodeocov*)	- 0.007	0.016	0.666
Household Income (*absdiff*)	- 0.047	0.029	0.102
Father’s education level (*nodeicov*)	- 0.059	0.085	0.489
Father’s education level (*nodeocov*)	- 0.036	0.073	0.626
Father’s education level (*absdiff*)	- 0.054	0.039	0.168
odegree(0)	2.888	0.26	<0.001***

b) Model 2

ERGM terms	Estimate	Std. Error	*p*-value
Edges	-7.363	1.369	<0.001***
Sex (*nodematch*)	3.575	0.388	<0.001***
Prosociality (*edgecov*)	0.28	0.129	0.03**
Household income (*edgecov*)	-0.002	0.025	0.924
Father's education (*edgecov*)	-0.058	0.1	0.566
odegree(0)	2.902	0.291	<0.001***

* Significant at $p < 0.1$; ** Significant at $p < 0.05$; *** Significant at $p < 0.001$

2.4. Discussion

The social network analyses reveal significant levels of preferential interaction. Highly prosocial individuals tended to have more friends (mostly other prosocial friends), while household income and father's education level does not have a significant influences on friendship. Household income and father's education are less important factors than prosocial attributes in explaining friendship formation. Still, the effect of prosociality on friendship formation is quite a bit smaller than that of sex-based homophily. While the effect of sex-based homophily is about 33.12 (=exp(3.5)) in both models in terms of odds of tie, the difference of due to prosociality between dyads of prosociality score 4 and dyads of score 2 (from Table 6) is 1.32 (=exp(4×0.137-2×0.137)) and 1.75 (=exp(4×0.28-2×0.28)) in model 1 and 2, respectively.

2.4.1. Plausible mechanisms for preferential interaction

Preferential interaction can come about through variety of causes: kin, reciprocity, costly signaling, neighborhood effects, niche, ostracism, punishment, and social group structure. We do not have evidence which of these is mainly responsible for preferential interaction in our sample. We can at least exclude kin-based explanations because there will be few sibling or cousins in the same grade of the same school. We think two plausible mechanisms responsible for preferential interaction are generalized reciprocity and cultural group selection.

Altruism by group selection may be nonexistent in other mammals since high levels of migration tend to erase between-group variation (assuming most of their behaviors are determined by genes) (Clutton-Brock, 2009; Richerson & Boyd, 2005). However, for humans, it is not true because cultural norms tend to drive people to behave in the interest of their group and conformity bias tends to propagate group beneficial norms (Richerson & Boyd, 2005; Bowles & Gintis, 2011). For high school students in our sample, where a small city constitutes a meta-population, cultural norms as well as neighborhood effects and social group structure may influence neighborhood quality in general and preferential interaction in particular.

2.4.2. Social network analysis and perspective switching

There has been much recent development in the field of social network analysis as a way of analyzing relationships and interactions among individuals. In particular, social network analysis can methodologically bridge the gap between individual process and group properties. For example, in social cohesion and social capital literatures, the influence of group-level conditions on individual behavior (e.g. crime and health-related outcome) has been tested through hierarchical linear models and multivariate analysis (Friedkin, 2004; Sampson et al., 2002; Putnam, 2000). Less explored is how individual-level interactions emerge as group-level structures or institutions.

Mapping the relationship between micro-level process and macro-level phenomenon has also been a primary concern of evolutionary theorists. But most recent applications of social network analysis on the evolution of cooperation have explored and interpreted social structure from the individual's perspective (e.g. Apicella et al., 2012; Fowler & Christakis, 2010), but not from a group perspective.

Since the evolution of altruism can be seen from both multilevel and individualistic perspectives, perspective-switching will reveal the other side of preferential interaction (Kerr & Godfrey-Smith, 2002; Dugatkin & Reeve, 1994; Sterelny, 1996). Social network analysis reveals from the bottom up, how individual interaction aggregates to group-level properties like group cohesiveness. Methodologically, social network analysis of friendship networks is similar to a contextual approach which assigns fitness to a lower level (i.e. individual) and treats the group as an environment of individuals (i.e. friendships of focal individual) (Kerr & Godfrey-Smith, 2002; Dugatkin & Reeve, 1994; Sterelny, 1996). Altruism can evolve when altruistic individuals are surrounded by other altruistic individuals. However, the picture is complete only when the same phenomenon is also seen from an aggregate perspective. The productivity of the group should outweigh the disadvantages incurred by altruists within a group. A group can be a transitional, ephemeral entity and can have a high turnover rate as long as preferential interaction is maintained. In that sense, this research only addresses half of the picture. A more complete picture would reveal the relationship between preferential interaction and group structure. In future research we will explore how regularities in dyad relationships correspond to between-neighborhood variation of prosociality. For example, we expect that a neighborhood with the highest preferential interaction measures will show highest neighborhood quality measures.

Besides mapping the relationship between micro-level processes and macro-level properties, this research proposes a new method using social network analysis for testing the preferential interaction necessary for the establishment of cultural group selection. Among the applications of social network analysis to the measure of preferential interaction, the relationship between centrality and altruistic propensities has been explored previously (e.g. Apicella et al., 2012). We extend their analysis using the ERGM framework that provides for broader and more refined tests of preferential interaction hypotheses. For example, using the ERGM framework, we were able to compare the independent effects of homophily and popularity; we found popularity was more important than homophily in our sample.

A weakness in this application is the self-reported answers in the survey, which may entail some biases. If sample size is small, ideally, we would use more direct measures of prosociality than self-reporting, perhaps measures of volunteering, reputation or food-sharing. Or, survey data would be supported by ethnographic and behavioral observations. .

We used friendship as an example of a cooperative relationship with non-relatives. While friendship is frequently mentioned as a model of reciprocity, friendship in human society does not conform to strict contingency (Silk, 2003; Hruschka, 2010). People tend to lose track of past contingencies and forget their past benevolent behaviors to others. In order to evaluate the structure of cooperation in a large scale, we would, ideally, consider all the possible kind of prosocial and antisocial interactions. A friendship network is just one of many possibilities. However, as a proxy for reciprocal altruism, friendship may be a good starting point to further explore the structure of cooperation. In addition, gathering data on friendship is relative easy and less time consuming.

Chapter 3: Between-neighborhood variation in "neighborhood quality": the issue of pluralism.

3.1. Introduction

In the previous chapter, I argued that preferential interaction is a necessary condition for the evolution of altruism. I then demonstrated that, using social network analysis on a sample of friendships, prosocial individuals tend to preferentially befriend other prosocial individuals. Further, I argued that "perspective switching" (using both an individual perspective and group perspective) can reveal a more complete picture of social interaction. We might also expect that a positive association will occur between neighborhood quality (measured by survey or through demographics) *and* preferential interaction among prosocial individuals. In other words, in a low quality neighborhood, a lower level of preferential interaction is expected and, in a high quality neighborhood, a higher level of preferential interaction is expected.

Here, I explore and test three interrelated things. First, I analyze contributing factors to self-reported prosociality. Second, I examine the presence of between-neighborhood variation of prosociality and then explore whether between-neighborhood variation of prosociality has an effect on individual prosociality. Lastly, I test whether neighborhood structure is responsible for preferential interactions in friendships.

The relationship between individual interactions and emergent properties of groups has been of great interest to social scientists as well as evolutionary theorists. Concerning this relationship, individualists would attribute aggregate phenomenon directly to individual decisions (or interaction among individuals), while multilevel selectionist accredit the same phenomenon to the joint sum of population structure and individual properties. Debates between the two camps—the so-called "group selection controversy"—has received much attention. Another perspective that has received less attention (at least, in anthropology) is that same set of phenomena can be interpreted from both perspectives (Dugatkin and Reeve 1994; Sterelny 1996; Kerr and Godfrey-Smith 2002; Waters 2005; Okasha 2006). This viewpoint is called pluralism or perspective switching. Pluralists insist that switching back and forth between perspectives is heuristically useful, although in some situation one perspective is causally more accurate or provides more insight than the other. In a multilevel framework, altruists can proliferate through its effect on group productivity. On the other hand, from the individual perspective, altruists have a fitness advantage because they are surrounded by other altruists. In this chapter, I test hypotheses from a pluralist framework and explore the relationship between individual interactions and group structure.

Here the distinction between two types of group selection is critical. In multi-level selection 2 (or abbreviated as MLS2, *sensu* Damuth and Heisler, 1988 and Okasha, 2006), the fitness of a group is the only concern and we do not track the changing frequency of individuals. MLS2 thus deals with the reproduction of offspring groups. Groups are able to "reproduce", by splitting or by sending out it members. Wynne-Edward's (1962) group selection models belong to this case. In contrast, in multi-level selection 1 (MLS1), individuals are "focal" units and groups are *means* by which an individual character (e.g. altruism) might increase its frequency relative to the alternatives. MLS1 deals with the evolution of individual characters in a group-structured population. David Sloan Wilson's trait group scenario fits in this case (Wilson, 1975;

Sober and Wilson, 1998). Pluralism is only applicable to MLS1 because an individual perspective is not available in MLS2.

3.1.1. David S. Wilson's revival of group selection

One of the problems in naïve group selection theory is a belief that higher-level selection easily trumps lower-level selection. It was severely criticized by George Williams (1966). Williams was right in that selection in a higher level than individuals requires special conditions. Probably most of Wynne-Edward's proposed mechanisms for population size regulation (e.g. didactic display in birds) cannot satisfy these special conditions. However, Williams has gone so far to declare that within-group selection always wins the race over between-group selection. At least, in a few species where population structure is preferable for group selection, group selection can be clearly demonstrated (e.g. eusocial insects (Wilson and Hölldobler, 2005), parasites virulence (Wade et al., 2010) and humans (Richerson and Boyd 2005; Bowles and Gintis, 2011)). Further, the conditions for preponderance of between-group selection over within-group selection are not as stringent as previously assumed (Sober and Wilson, 1998; Wilson and Dugatkin 1997).

All group selection models before David Sloan Wilson's reframing of the concept require stringent conditions for group selection to occur. The group in those models was given individual-like properties such as constituting an enduring, cohesive, and functionally-organized entity with clear-cut boundaries among other such entities. In other words, all previous models are MLS2.

This picture changed with Wilson's trait group concept. Wilson defines a trait group as groups of individuals that share a common fate with respect to the trait under consideration (see Figure 3; Wilson 1975; Sober and Wilson 1998). In a trait group, the criterion of group boundary is behavior rather than spatial distribution because fitness-affecting interactions between group members occur through behavior. That means even if a group is spatially dispersed, as long as most interactions occur between members, a trait group can be said to exist. In addition, a trait group is defined on a trait-by-trait basis. Group composition differs for different traits. Consider a trait promoting helper's at the nest. Most of the time, the trait is only expressed toward it's siblings. So for most cases, the trait group of helper's at the nest character is sibships. In some cases, however, selected group of reciprocal partners are provisioning each other's offspring. They have a completely different composition then, where the trait group is reciprocal partners. Moreover, since a purely viscous population is not favorable for the evolution of altruism[1], there should be some mechanisms to export the productivity of altruistic group (Wilson , Pollock and Dugatkin 1992). Examples of exporting altruism are periodic mixing and, in the human case, transmission of prosocial cultural norms. Because of periodic blending and lack of discrete spatial boundaries, for some researchers (e.g. Maynard-Smith, 1976, 1987), trait group selection is not regarded as a "genuine" group selection. For Maynard-Smith, the trait group is too fleeting.

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[1] Even in a altruistic group, the frequency of altruist decreases over generations.

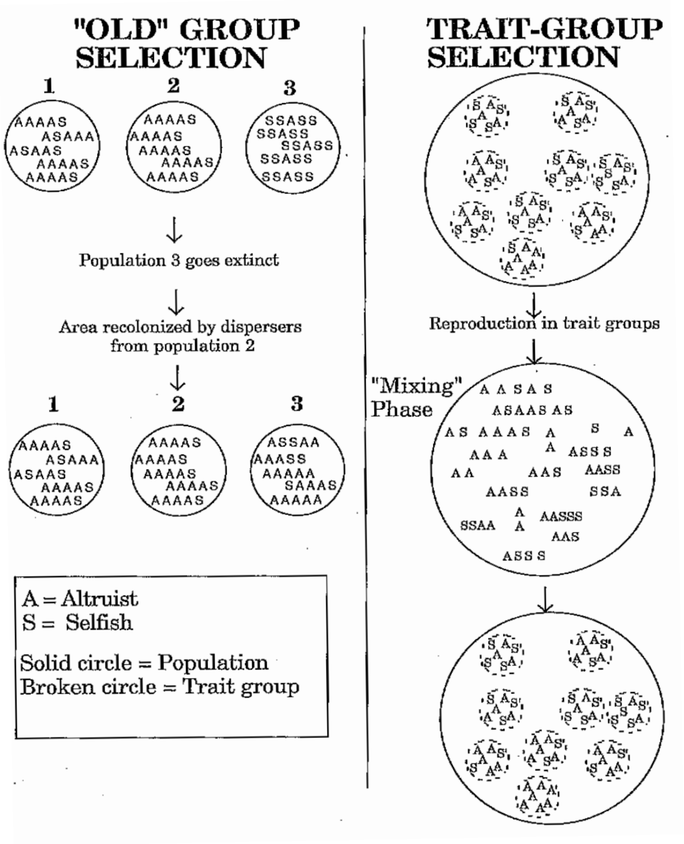
"OLD" GROUP SELECTION
TRAIT-GROUP SELECTION
1
2
3
Population 3 goes extinct
Area recolonized by dispersers from population 2
Reproduction in trait groups
"Mixing" Phase
A = Altruist
S = Selfish
Solid circle = Population
Broken circle = Trait group

Figure 3. A comparison between the "old" group selection and trait group selection models (from Dugatkin, 1997): In both models, the altruist suffers from within-group interactions. That is to say, the frequency of altruists decreases over generations. The difference lies in the presence of a"mixing phase" in the trait group model. In the old model, the only way of spreading altruists in the meta-population is by colonization. However, in the trait group model, altruists can spread in various ways during mixing phase.

At the extreme, Sober and Wilson (1998) insist that Tit-for-Tat can it increase its frequency in the iterated prisoner's dilemma game because of the superiority of between-group selection over within-group selection. Within-group selection always prefers all D to TFT since the first move by TFT is always cooperation. However, between-group selection favors TFT since (C, C) is fitter than (D, C) and (D, D). Although their logic is clear and correct, treating temporary pairs in the iterated prisoner's dilemma as a group causes much confusion over the definition of a group in some examples. In effect, in most cases of the evolution of altruism[2], a trait group can be defined; and, in some cases of those, the trait groups are transient, perhaps to the extreme of having a one-shot interaction. So some researchers argue that group selection by transient trait group should be called population-structured selection to prevent confusion (e.g. Sterelny, 1996). Furthermore, while most other examples of trait group selection assume a structured population (which means the existence of, at least, loose boundaries between groups), TFT can evolve under random interaction.

3.1.2. Why pluralism?

As shown in Kerr and Godfrey-Smith (2002) and Damuth and Heisler (1988), the Price equation for group selection can be converted to an equation for individual perspective without losing any information. Those mathematically equivalent equations simply package information differently. However, Wilson and Sober criticize pluralism on the ground that only the multilevel selection perspective can explain the *causal pathway* for the evolution of altruism (Sober and Wilson, 1998, 2002; Wilson, 2008; Wilson and Wilson, 2007). To them, even though the individual perspective can predict the evolutionary trajectory of altruism and the equilibrium state (predominance of altruism or selfishness), the perspective is not causally appropriate. To them, for example, while both individual and multilevel perspectives can predict the evolution of TFT in the iterated prisoner's dilemma game, only the multilevel perspective can explain why TFT gains a fitness advantage over other variants. Having embraced most transient cases of interaction as a trait group, all evolution of altruism can be described in terms of multilevel selection: altruism evolves when between-group selection is stronger than within-group selection.

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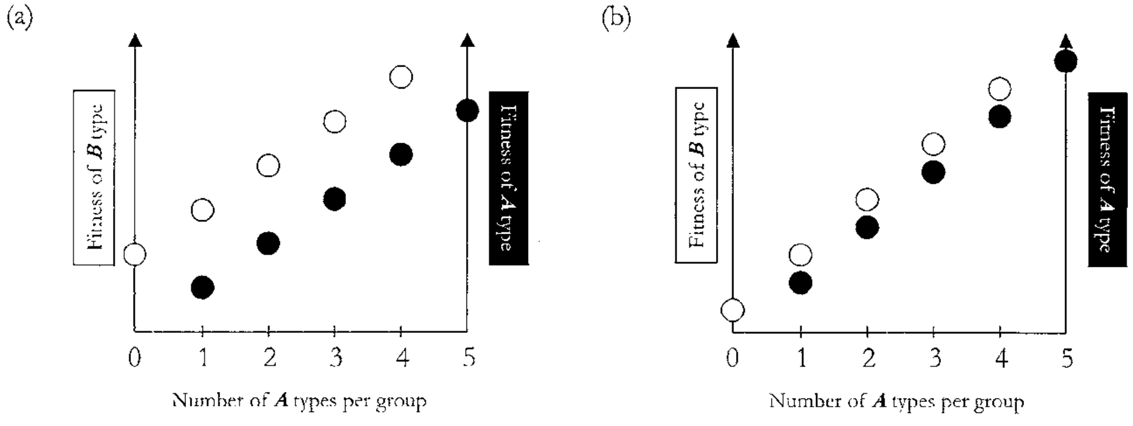
[2] The exception will be some weak selection cases that do not require structured interaction for the evolution of altruism.

Figure 4. Strong vs. weak altruism (from Kerr and Godfrey-Smith, 2002). Assume a group composed of 5 individuals and random interaction among group members. The two graphs shows fitness of A type (altruist) and B type (non-altruist) (on the *y*-axis) depending on number of A type per group (on the *x*-axis). Graph (a) represents the case of strong altruism and graph (b) weak altruism. The solid circles shows the fitness of altruist and open circles shows the fitness of non-altruist. Both cases satisfy the definition of altruism by Sober and Wilson (1998) since with each additional altruist in a group, average fitness increases *and* non-altruists always has higher fitness than altruist. Preferential interaction among altruists (or any other constraints for conflict resolution) is needed for strong altruism. On the other hand, weak altruism can evolve under random interaction.



However, though I agree with Wilson and Sober's argument of causal adequacy, I disagree with their claim that all cases of the evolution of altruism by population-structured selection should be described only in multilevel term. As succinctly explained by Kerr and Godfrey-Smith (2002), the individual perspective (or *contextual* perspective) is stronger in predicting which character evolves. The heuristic value of the individual perspective can be illustrated by the comparison of fitness structure between strong and weak altruism (Figure 4). If fitness structure is weak altruism (Panel b), it is advantageous for a non-altruist to become an altruist since the fitness of an altruist when $n+1$ altruists are present is always greater than the fitness of non-altruist when n altruists are present. However, in a strong altruism fitness structure (Panel a), the same conversion is not favorable since the fitness of an altruist when $n+1$ altruists are present is less than the fitness of non-altruist when n altruists are present. This type of heuristic is called "last member analysis." It is a way of asking that "if you are the last member to join a group, which strategy is more advantageous for you?" Last member analysis is not easily demonstrated from the multilevel perspective.

The altruistic strategy is an evolutionary stable strategy (ESS) in the weak selection case. In contrast, since the conversion from non-altruist to altruist does not pay in the strong selection case, the selfish strategy is ESS. Therefore, a mechanism for conflict resolution at the individual level must be present for the evolution of altruism in the strong selection case. One such mechanism is preferential interaction among altruists, consequently making exploitation by selfish individuals more difficult. Since positive assortment is a necessary condition for the evolution of strong altruism, the individual perspective is sometimes called frequency dependent selection (Okasha, 2006). The fitness of an altruist critically depends on the frequency of other altruists in its immediate network. It is not coincidence that all successful models of the evolution of altruism share preferential interaction feature (Bowles and Gintis, 2011).

In addition to accurately predicting which character will evolve, another virtue of the individual perspective lies in direct testing of preferential interaction. Most multilevel selection models suppose random interaction within a group. Or, they assume, at least, members of same group interact more frequently with each other than with outsiders. The random interaction is often parameterized by equally distributed benefits toward all members of group. We need to demonstrate altruistic individuals are actually surrounded by other altruists and interact more frequently with them. Here, the level of preferential interaction is measured in friendship network.

In sum, multilevel and individual perspectives are complimentary. Both perspectives are good at detecting the proper cause for the evolution of altruism (cf. Sober and Wilson 1998 vs. Okasha 2004). Using a multilevel perspective, the contribution of group structure to the spread of altruistic genotype-phenotype can be revealed. Viewed from an individual perspective, we can explore the fitness structure of the population, predict which strategy is beneficial under the fitness structure, and test preferential interaction more directly.

3.2. Method

Fieldwork was conducted in Pohang, South Korea between March and June of 2012. Pohang is famous for its steel industry (the largest steel company, POSCO, in South Korea is there) and its economy depends on the steel industry and shipbuilding. The population of Pohang is about 5 hundred thousand. Like other South Korean cities, Pohang is ethnically highly homogenous (the proportion of foreigner is less than 0.8%).

A survey (see Box 2) was implemented 1st and 2nd grade high school students (these correspond to the 10th and 11th grades in the US) in 8 high schools out of 19 schools in Pohang. High school students were used as the target population for two reasons. First, after graduation, high school students tend to leave their natal communities for college. Hence, while still in high school, self-assessment of social support will reflect 'true' neighborhood quality, *sensu* Wilson et al. (2009). And second, survey response rate among high school students tends to be higher than that of adults (Converse & Stanley, 1986) and a high response rate is required for social network analysis (Wasserman & Faust, 1994). In order to implement the survey, permission from school representatives was required. School representatives were contacted through referrals or through my personal network. Among the 9 schools from which I sought permission to do the research, permission was granted in 8 schools. The survey was implemented through either online or paper questionnaires. Both versions contained the same 39 items given in the same order. Among 3,074 participants from 8 schools, 152 observations were excluded for a failure to answer more than 10 questions, or for answering questions identically (e.g. 1-1-1-1) or by using a recognizable patterns (e.g. 1-2-3-4-5), or for failure to provide demographic information. A total of 2,922 individuals provided questionnaires that were used in subsequent analyses.

The survey is a modified version of the survey used in Wilson et al.'s (2009) study from Binghamton Neighborhood Project. The questionnaire consisted of demographic questions (address, household income, father's education, and mother's education), 8 questions about individual prosociality, 31 questions about social supports and list of seven closest friends. Individual prosociality questions (8 questions) measured a respondent's willingness to maintain a cooperative relationship with other people (e.g. "I am helping to make my community a better place."). Social support questions (31 questions) ascertained perceptions of social support from immediate neighbors (e.g. "I have good neighbors who help me succeed."), and are subdivided into seven categories that include family, school, religion, friends, extracurricular activities, neighborhood and general. These categories are designed to capture seven important domains of prosocial activities for Korean high school students. Answers were given on a five-level Likert scale (1=not at all to 5=always). Individual prosociality and social support scores were calculated by averaging answers for each category. For example, individual prosociality was obtained by averaging 8 individual prosociality scores. In addition to individual prosociality and social support questions, participants were asked to list their seven closest friends with unique identifiers that included names, addresses and home rooms.

In addition, a focus group interviews were conducted on a survey subsample (*N*=40) to provide qualitative context on issues of social support.

BOX 2 Survey questions

Prosociality
1. “I think it is important to help other people.”
2. “I resolve conflicts without anyone getting hurt.”
3. “I tell the truth even when it is not easy.”
4. “I am helping to make my community a better place.”
5. “I am trying to help solve social problems.”
6. “I am developing respect for other people.”
7. “I am sensitive to the needs and feelings of others.”
8. “I am serving others in my community”

Social support: Family
9. “I feel safe and secure at home”
10. “I am included in family tasks and decisions”
11. “I am spending quality time at home with my parents/guardians”
12. “I have parents/guardians who help me succeed”
13. “I have parents/guardians who urge me to do well in school”
14. “I have a family that gives love and support”
15. “I have parents/guardians who are good at talking with me about things”
16. “I have a family that knows where I am and what I am doing”

Social support: school
17. “I feel safe at school”
18. “I have a school that gives students clear rules”
19. “I have a school that enforces rules fairly”
20. “I have a school that cares about kids and encourages them”
21. “I have teachers who urge me to develop and achieve”
22. “You feel like you are part of your school.”
23. “You are happy to be at your school.”

Social support: Friends
24. “How much do you feel that your friends care about you?”
25. “I have friends who set good examples for me”

Social support: religion
26. “I am involved in a religious group or activity”
27. “How often do you attend religious services?”

Social support: neighborhood
28. “I have a safe neighborhood”
29. “I have good neighbors who help me succeed”
30. “I have neighbors who help watch out for me”

BOX 2 (cont.): Survey questions

Social support: extracurricular activities
31. “I am involved in a sport”
32. “I am involved in creative things such as music and painting”

Social support: general
33. “I feel valued and appreciated by others”
34. “I am encouraged to try things that might be good for me”
35. “I am encouraged to help others”
36. “I am given useful roles and responsibilities”
37. “I have adults who are good role models for me”
38. “I have support from adults other than my parents/guardians”

39. For your seven closest friends, provide a full name, grade, class and the neighborhood in which he or she lives.

3.3. Results

3.3.1. Assessing contributors to self-reported prosociality

The mean and standard deviation of individual prosociality and social support scores by gender are presented in Table 7. Since there were nine participants whose gender are uncertain, the number of male and female participants does not add up to the number of total participants. Females tended to score greater than males for all indices; but, differences in prosociality and household income are not significantly different.

Table 7. Individual prosociality scores, social support scores, household income, father's educational attainment and mother's educational attainment (and standard deviation) by gender

	All participants (N=2,922)	Male (N=1,577)	Female (N=1,336)
Prosociality[a]	3.005 (0.604)	2.99 (0.615)	3.023 (0.591)
Social support[a] *	2.939 (0.592)	2.921 (0.572)	2.963 (0.614)
Household income[b]	3.797 (1.677)	3.753 (1.592)	3.844 (1.767)
Father's education[c]***	6.993 (1.296)	6.922 (1.331)	7.073 (1.246)
Mother's education[c]****	6.684 (1.221)	6.556 (1.267)	6.83 (1.149)

a. Possible range for individual prosociality and social support is from 1 (least) to 5 (most)

b. 1. Less than $25,000

2. More than $25,000 but less than $40,000

3. More than $40,000 but less than $60,000

4. More than $60,000 but less than $100,000

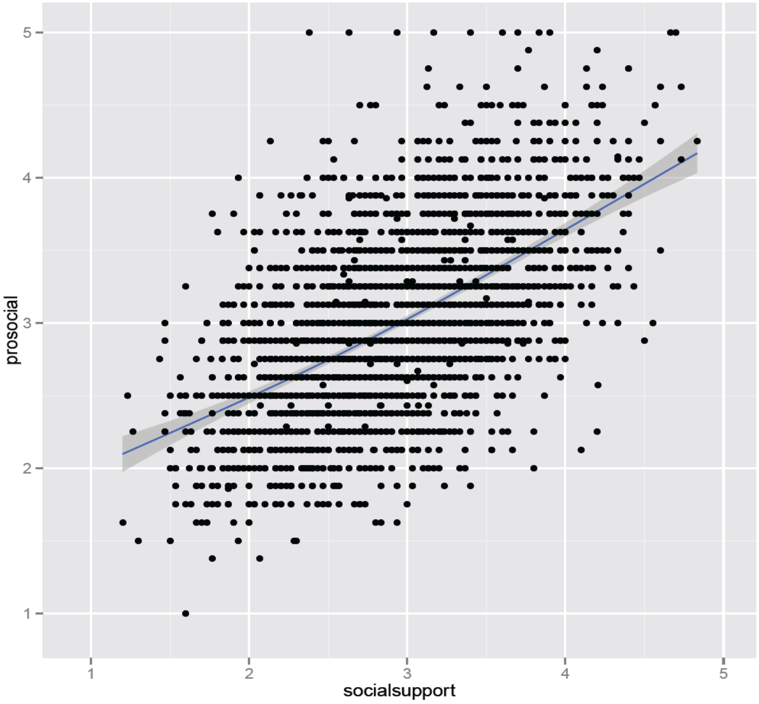
5. More than $100,000

c. 1. Elementary school dropout 2. Elementary school graduate 3. Middle school dropout 4. Middle school graduate 5. High school dropout 6. High school graduate 7. College dropout 8. College graduate 9. Postgraduate

Note: *t*-test of difference between genders: * $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$**** $p < 0.001$

To relate prosociality to social support, I examined the simple correlation between prosociality and total social support. There is a strong positive relationship between the two (spearman's R^2= 0.5749, *N*= 2,922). As shown in Figure 5, the more social support an individual receives, the more cooperative she is likely to be.

Figure 5. Scatter plot of self-reported prosociality against total social support with fitted line. There is a strong positive correlation between the two (R^2 = 0.5749).



Having established the positive relationship between total social support and prosociality, I conducted multivariate regression to explore which domains of social support is most responsible for prosociality. Four additional covariates — gender, household income, father's educational attainment and mother's educational attainment — are included in the model. For each domain of social support, the average score is calculated for all questions under the same category. Social support from family, for example, is calculated from the average scores for 8 questions (from 9th to 16th question in Box 2). After running the full model with all eleven covariates included, insignificant covariates ($p < 0.1$) were dropped out in a stepwise fashion. Results of the full model and the most parsimonious models are given in Table 8.

Note that the number of observation increased in the parsimonious model because data were missing for father's and mother's educational attainment (167 and 171, respectively) and household income (721),. While father's and mother's educational attainments (which are indirect measures of socioeconomic status in South Korea) are marginally significant in the full model, both variables were eliminated in the parsimonious model; thus, significance of these two variables is not robust.

The result of this multivariate analysis is similar to Wilson et al. (2009) for Binghamton, NY. First, with the exception of religion, each social support domain is significant and positive. This means that, in order to be prosocial, an individual needs multiple sources of social support during their social development. Second, besides the domains of social support, none of the other covariates (e.g. household income and father's educational attainment) predicted individual prosociality.

Table 8 Multivariate regression result to predict self-reported prosociality

Covariates	Full model Standardized beta (standard error) (N=2,124, R^2= 0.3802)	Most parsimonious model Standardized beta (standard error) (N=2,908, R^2= 0.3884)
Social support (SS) from family	0.038 (0.015)**	0.051 (0.013)****
SS school	0.032 (0.016)**	0.043 (0.013)***
SS friends	0.148 (0.015)****	0.138 (0.012)****
SS religion	0.008 (0.008)	—
SS neighbor	0.038 (0.014)***	0.037 (0.012)***
SS extracurricular activities	0.06 (0.011)****	0.056 (0.009)****
SS general	0.239 (0.018)****	0.236 (0.015)****
Father’s educational attainment	0.019 (0.01)*	—
Mother’s educational attainment	−0.018 (0.011)*	—
Household income	0.002 (0.006)	—
Gender	−0.034 (0.022)	—

* $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$**** $p < 0.001$

3.3.2. Neighborhood quality and its effect on individual prosociality

To explore the influence of neighborhood on individual prosociality, I conducted a hierarchical analysis using six variables at the second level (i.e. mixed effect), including neighborhood quality, voter turnout, population density and average household income. “Neighborhood quality” is an aggregate measure obtained by computing the average of individual prosociality for each neighborhood. Excluding 11 neighborhoods where the number of survey participants was less than 10, the range of neighborhood quality was from 2.84 to 3.125 (Figure 6). Voter turnout is a potentially indirect measure of neighborhood quality that is not based on the survey. The voter turnout was calculated from public elections records by the sum of valid and invalid ballot divided by all registered voters.[3] The assumption here is that voting is a costly activity for individuals (e.g. time and travel) but beneficial for society (e.g. sustaining democracy). The range of voter turnout was from 46.7% to 62.7% in the 19 neighborhoods examined. The range of household income is from 2.94 to 4.54 (for the meaning of this scale, see Table 7). Social support from religion is not included in the model since it had no effect on prosicality in the multivariate analysis.

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[3] Unlike the United States, voters who live in country do not need to register to vote—they are automatically registered upon becoming eligible to vote.

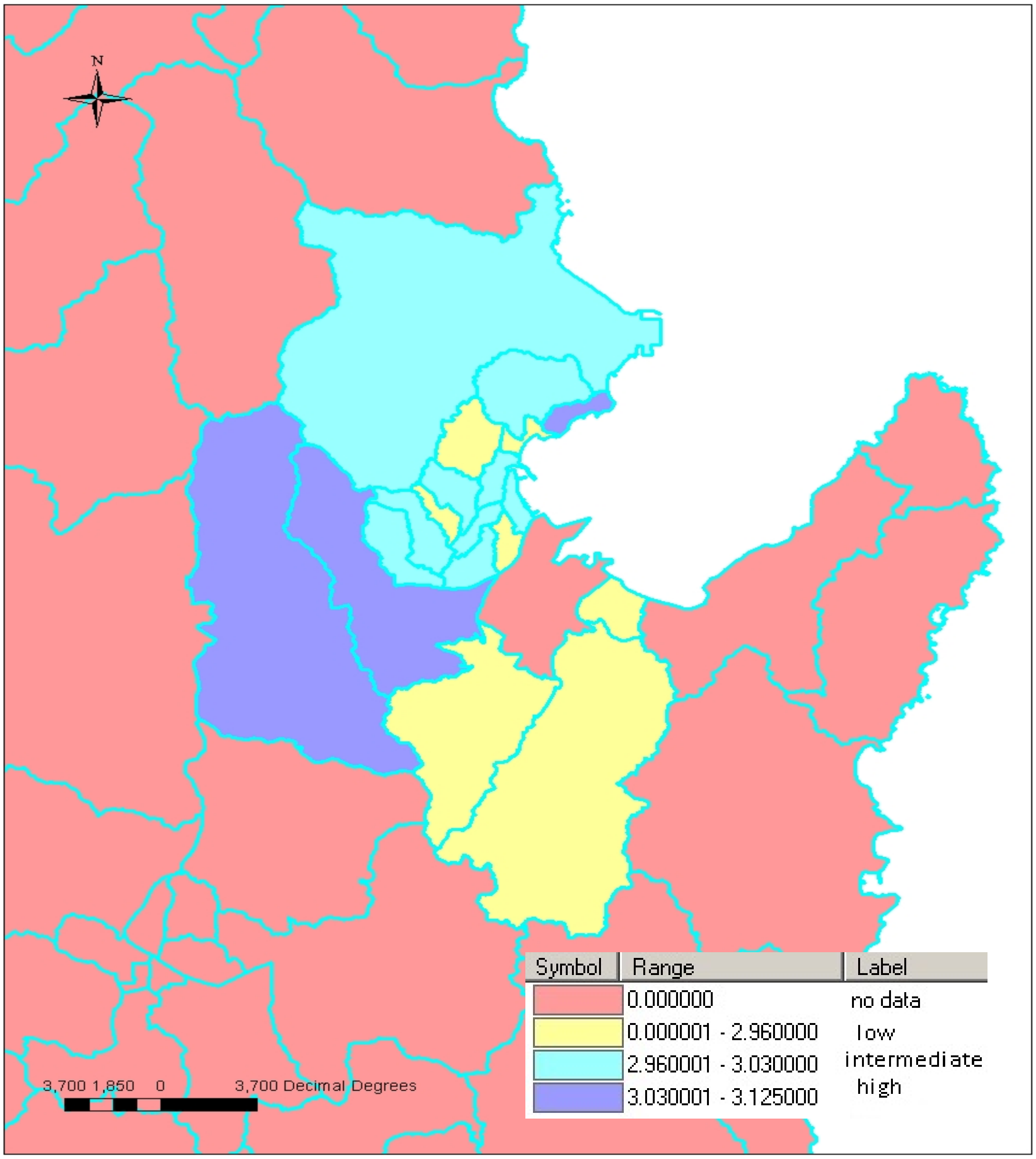

N
Symbol | Range | Label
🟥 0.000000 no data
🟨 0.000001 - 2.960000 low
🟦 2.960001 - 3.030000 intermediate
🟪 3.030001 - 3.125000 high
3,700 1,850 0 3,700 Decimal Degrees

Figure 6. Neighborhood quality for Pohang and its vicinity, South Korea. Neighborhood quality was calculated by averaging prosociality scores within each neighborhood (i.e. administrative block).

The result of hierarchical analysis is presented in Table 9. Except for neighborhood quality, none of second level predictors were significant. In addition, when a possible cross-level interaction was entered into the model (e.g. neighborhood quality is mediated through neighbor), only cross-level interaction of neighborhood quality and social support from school was significant ($p < 0.05$). Parameter sizes for first level predictors are similar to the ones in the multivariate analysis. The magnitude of the neighborhood quality parameter (0.002) is small but significant which suggests that where student live is *weakly* associated with individual prosociality.

Table 9. Result of hierarchical model with individual prosociality as dependent variable (*N*=2,908)

Covariates	Parameter size (standard error)
First-level predictors	
SS family	0.051 (0.013)****
SS school	0.043 (0.013)***
SS friends	0.138 (0.012)****
SS neighbor	0.037 (0.012)***
SS extracurricular activities	0.056 (0.009)****
SS general	0.236 (0.015)****
Second-level predictors	
Neighborhood quality	0.002 (0.063)**

* $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$**** $p < 0.001$

3.3.3. Test of Pluralism

To explore the pluralism of individual and group perspectives, I used subsample of 5 schools where survey response rate was higher than 85% since degrees in incomplete networks tend to be biased. The final sample size was 1,173 which is about a third of all survey participants. Among three methods that I introduced to test preferential interaction in chapter 2, the most exact method, ERGM, cannot be used here because of non-convergence problems in estimation. Here, I explore whether prosocial individuals tend to have more friends than less prosocial individuals. I constructed five directed friendship networks from 5 schools. There were a few individuals who listed friends in other schools. However, those between-school friendships are ignored because of difficulties in identifying the individuals. Some subjects did not write a school name of a friend and, even if school name is provided, presence of a different person with the same name made identification difficult. Then, out-degree, in-degree and reciprocal degree for each individual are extracted from the friendship network.

I ran multivariate analysis to predict individual prosociality using in-degree, out-degree and reciprocal degrees as independent variables. None of the degree variables significantly predicted prosociality.

Then, I tested whether neighborhood quality could predict number of friendships. For each neighborhood, I calculated average out-degree, in-degree and reciprocal degree. Pairwise correlation between neighborhood quality and the three degree measures gave an unexpected result: none of the correlations was statistically significant.

3.4. Conclusion and Discussion

Multivariate analysis suggests that the more prosocial individuals have a richer background of social support. Hierarchical analysis further indicates that where a student lives is *weakly* related to how cooperative she is. This weak relationship might well be explained by the low variation in neighborhood quality that ranged from 2.84 to 3.125 out of a possible range of 1 to 5. The between-neighborhood prosociality variation found in Pohang was much smaller than the variation in Binghamton (33 to 77.93 from possible range of 0 to 100). The difference in range was 7% for Pohang vs. 45% found in the Binghamton Neighborhood study. Both studies use the same questions for prosociality scales.

The absence of a significant correlation between degree measures in the friendship network and neighborhood quality may result from this small between-neighborhood variation. Another possibility is that a friendship may not be representative of a relationship that affects fitness. The cultivation of friendships may not require much sacrifice so a friendship relationship might be characterized by weak altruism (which does not require preferential interaction). A better example of fitness-affecting network might be a social interaction that involves some cost from the actor. For Korean high school students, examples might be a scholastic tutoring relationship or community volunteerism.

Recent research by Apicella et al. (2012) among the Hadza people of Tanzania also finds no relationship between the number of preferred partners and cooperativeness. They constructed two kinds of social network. One was based on the preferred campmates and the other was based on the list of people whom they are willing to share honey sticks. Both social networks are roughly comparable to friendship network in this study. Researchers measured individual prosociality by asking the number of honey sticks (from zero to four) that they are willing to anonymously contribute to common pool where it would be tripled by researchers and equally distributed to band members. Altruists tended to select other altruists and non-altruists tended to select other non-altruists in both networks. This homophily has the result that altruists had similar levels of in-degrees and out-degrees as non-altruists. Considering the correspondence between Apicella et al. (2012) and this study, I may need to develop a new social network tool to differentiate between homophily among altruists *and* homophily among non-altruists.

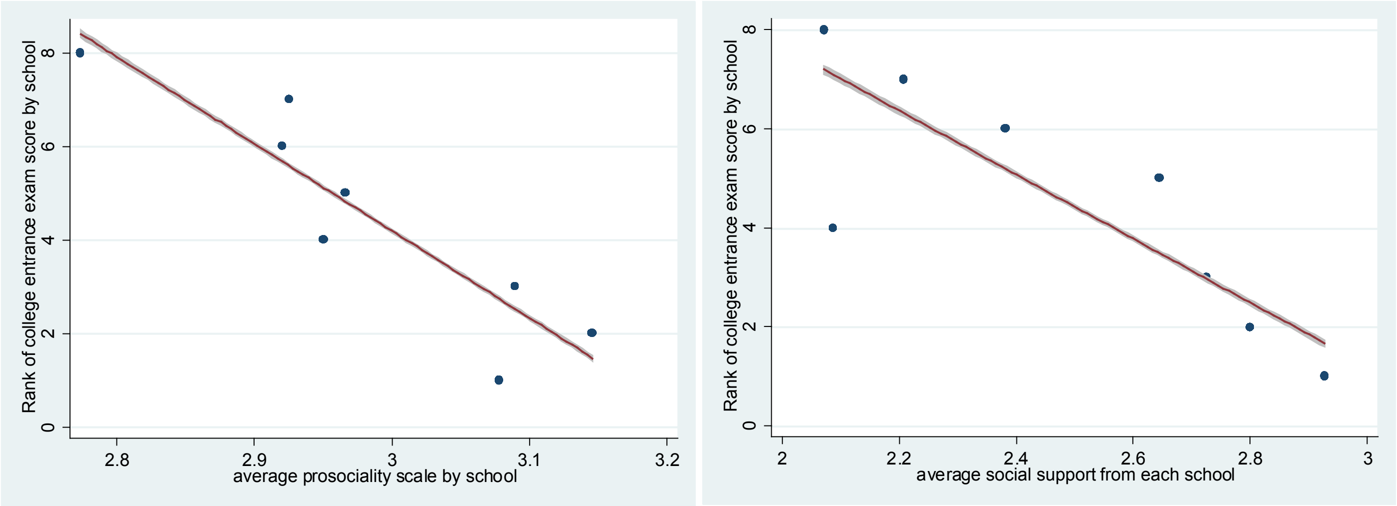
How, then, can emergent properties of a neighborhood influence individual prosociality? I suspect its effect is mainly mediated through school since Korean high school students spend most of their active time in the school during weekdays. Most high school students in Pohang go to school between 7am to 7:30am and return home between 9pm to midnight. The perception of school life was generally not positive among most Korean high school students in my study. The level of subjective happiness of Korean students is the lowest among 26 developed countries (Kwon, Lee and Song 2012). Excess competition is probably the best description of the Korean educational system and for the lives of Korean high school students. Competition among schools and within school is persistent. Attendance at special schools (e.g. international school and science school) and elite homerooms within a school are considered stepping stones to better scores on college entrance exams. National and school resources are disproportionately given to special schools and elite homerooms. In my focus group interviews, students revealed their discomfort with unfair treatment by teachers and the school. For example, a participant said “considering we pay the same amount of money to school and to the government, it is unfair that only elite students are specially treated.” Excess competition and unequal division of resources may be detrimental factors to the social evolution of prosociality in Korean high school students.

Further, the hierarchical analysis showed a mediation effect of school. When a cross-level interaction term between neighborhood quality (2nd level covariate) and social support from neighbors (1st level covariate) is entered into the model, the term is not significant. However, when a cross-level interaction term between neighborhood quality and social support from school is entered into the model, the term is statistically significant ($p < 0.05$).

A strong positive association between school quality measures and ranks of average college entrance exam scores suggests that school life is an important domain of Korean high school students (see Figure 7). School quality measures can be obtained in two ways: the average prosociality score *and* the average social support from school are calculated for each school. Both measures of school quality are strongly correlated with college entrance exam scores (in both correlation: $p < 0.0001$). In other words, the higher college exam score is, on average, the more prosocial the student in the school is *and* the more social support from the school the student receives.

I conclude by restating my findings. Preferences for helping others are affected by multiple sources of social support and places of residence. Here the individual perspective is investigated through friendship popularity of prosocial individuals and the group perspective is examined through neighborhood quality. Although the result does not demonstrate correspondence of both perspectives, the shortcomings itself calls for better research tools for preferential interaction and group productivity.

Figure 7. Scatter plot of rank of college entrance exam score against alternative measures of school quality scores. The rank of college entrance exam scores by school is from *Education, Culture, Sports, Tourism committee* of *the National Assembly of South Korea* (http://educulture.na.go.kr/). In (a), the school quality is average prosociality scores for each school. In (b), the school quality is average social support scores. In both plots, each dot is a school. The strong association indicates that school with high entrance exam score tends to have prosocial students who also have higher perception of social support from the school.



a)

b)

Chapter 4: External Validity of Experimental games: Can game behavior explain within-group and individual variation of prosociality?

4.1. Introduction

That many experimental game results do not conform to the self-interest axiom is regarded as evidence for strong reciprocity (Fehr and Fischbacher, 2002, 2005; Bowles and Gintis 2011; Camerer 2003). Strong reciprocity is a predisposition to reward or punish others, often at personal cost, even when it is impossible to expect that these costs will be recovered at a later date. For example, even when reputation building is impossible, the observation that game participants non-strategically punish violators of social norms is taken to be strong reciprocity (Engelmann and Fischbacher 2009).

This evidence, however, does not mean all people are unconditional cooperators. There may be conditional cooperators and free-riders operating within a social group in addition to unconditional cooperators (Fishbacher, Gächter and Fehr, 2001; Fehr, Fishbacher, and Gächter, 2002). That is, there may be substantial heterogeneity in strategy among individuals of a population. In addition, people may change their strategy based on incentives, game structure, the possibility of punishment, and other contexts so that a tiny fraction of self-regarding individuals may trigger aggregate selfish outcome in the population (Camerer and Fehr, 2006).

Population heterogeneity, however, does not hamper the interpretation that game behavior tells us something about a population and its culture as a whole. A series of cross-cultural studies by Henrich and colleagues exemplify this (Henrich et al., 2005; Henrich et al. 2006; Henrich et al. 2010). They found a very large degree of variation in game offers and punishment but none of the game results in any culture approximated the self-interest axiom (i.e. that most behaviors can be explained as maximizing the payoff to the actor). Sixty eight percent (R^2) of the between-group variation in offer size was explained by two variables: (1) the amount of cooperative activity in production and (2) market integration (a group measure of participation in wage labor and trading). It is not just game structure and contexts, but cultural norms and institutions matter as well. Game behaviors seem to reflect how social institutions and livelihood frame social interactions and shape social learning. The higher the payoff to cooperative interaction in everyday activities, the greater level of prosociality, expressed as egalitarian offers, found in experimental games. Also, the level of engagement in market exchange seems to enhance motivations and expectations related to trust, fairness and cooperation (Bowles, 1998).

While game behavior seems to reflect intergroup variation (i.e. inter-ethnicity) in culture, within group variation (i.e. within ethnicity, between villages and between individuals) in game behavior is not well understood (Henrich et al., 2005; Gurven and Winking, 2008; Hill and Gurven, 2004; cf. Lamba and Mace, 2011). Logically, if game behavior can explain intergroup variation, it should explain some of within-group and individual variation. If not, it might be an example of a Simpson's paradox (Sober 1984). In this paper, we empirically evaluate predictors for within group and individual variation. We do so by implementing experimental games on a city-wide sample of high school students in Pohang, South Korea. The external validity of game behavior is examined both between villages and at the individual level.

This paper is organized as follows. First, three experimental games are introduced. Then, we present the group level results summary of experimental games which can be interpreted as altruistic propensities among high school students in Pohang. Next, we explore the relationship between game behavior and individual characteristics potentially relevant to cooperation. Lastly, we examine whether between-village variation in game behavior is explained by individual or village level variables.

4.1.1. Experimental Games

Three experimental games are used to measure social preference. The first game is called the *ultimatum game* (henceforth, UG). In UG, two anonymous participants are given a sum of real money ("endowment," say \$10) in a one-shot interaction. Person A, the proposer, can offer a portion of endowment (say \$4) to Person B, the respondent. The respondent either rejects or accepts the offer (\$4). If the offer is accepted, the respondent receives the offer and the proposer takes the endowment minus the offer (\$6). If the offer is rejected, both players get nothing. The expectation under the self-interest axiom, for a one-shot, anonymous game is that the respondent will accept any positive offer. Therefore, the self-interested proposer should offer the minimum positive amount (e.g. \$1). However, actual behavior observed in UGs defies the self-interest axiom. The average offer is 30% to 40% of the endowment with the modal offer being half. Offers under 25% are rejected about half the time, even with high monetary stakes (cf. Slonim and Roth, 1998; Cameron, 1999). In UG, proposers may behave “generously” either because they fear rejection or because they are purely altruistic. In other words, the reason for a generous offer by a proposer is uncertain.

The second game is called the dictator game (henceforth, DG). The only difference between UG and DG is that person B cannot reject the offer. Knowing that the recipient cannot reject the offer, a selfish proposer will offer nothing. The game is played as a one-shot anonymous interaction. Because of this, the proposer's offer provides one measure of altruism that is not directly linked to kinship, reciprocity, future interactions, or the immediate threat of punishment (Henrich et al. 2006). That is, the DG eliminates fear-of-rejection that can happen in the UG. Results of such experiments tend to find a mode of zero and mean allocations of between 20% and 30%. A mean positive offer in the DG would suggest that, at least some proposers in the UG are purely altruistic (providing some monetary gain to Person B).

The last game is called the third party punishment game (henceforth, 3PPG). The difference between 3PPG and DG is the presence of a third player who is given one half of the endowment (say, $5) and must decide whether to do nothing or to use a portion of money ($1) to deduct money ($3) from the proposer's stake. If the proposer makes an offer (say, $4 for the recipient, keeping $6 for herself) and the third party decides not to punish, the recipient receives the offer ($4) and the proposer receives the rest ($6) and the third party keeps his money ($5). If the proposer makes an offer (say, $2 for the recipient, keeping $8) and the third party decides to punish, the proposer loses the deduction ($8 – $3 = $5) and the third party takes home the endowment minus the money she spends for punishment ($5 – $1= $4). Because this is also a one-shot anonymous game, a selfish third party would never punish a proposer. Knowing this, a selfish proposer will offer nothing to a recipient. Thus, the third player's willingness to punish provides a measure of willingness to punish at a cost (Henrich et al. 2006).

Although rejection in the UG and punishment in the 3PPG are both classified as altruistic behaviors, each may arise from different motives. While rejection in UG may be retaliation toward unfair treatment by the proposer, punishment in 3PPG lacks a sentiment of retribution. Essentially, the former is a form of self defense, whereas the latter is the action of a judge. Although recent evidence suggests that the motive for punishment toward a third party contains a desire for retribution rather than strategic motive to affect behavior (Falk, Fehr and Fischbacher 2005; Fudenberg and Pathak 2010), a punisher is relatively cooler and disinterested in the 3PPG than in the UG.

The importance of the 3PPG lies in one unique human quality: while personal retribution appears to be present in other animals, humans seem to be the only species that enforces cultural norms on a third party (Hill, 2009; Sterelny 2009; Riedl et al., 2012). In capuchin monkeys, for example, faced with a smaller award relative to a partner for a similar effort, several individuals refused an award (Brosnan and de Waal 2003). Third party informal sanctions have never been observed in other primates, or any other animals. Third party sanctions can stabilize cooperative cultural norms. Costly punishment is a mechanism by which such norms can remain stable against defectors (Fehr and Fischbacher 2004; Henrich et al. 2006; Mathew and Boyd 2011). Informal sanctioning can solve the problem of collective action where no formal institution exists to force cooperative norms (Fehr and Gächter 2002).

4.2. Subjects

Most game participants were selected as a stratified random sample of participants in a previous survey (see Box 3) conducted in six high schools in Pohang, South Korea. Game participant were randomly selected among the 1st and 4th quartile of individual prosociality measures (assessed in the survey that is introduced in the next section) as a way to increase the variation of game behavior. In one of the six schools, this stratified sampling procedure could not be accomplished for logistic reasons, so each experiment was implemented for participants drawn from a randomly selected homeroom. All games were implemented in a computer lab within each school. With the exception of two schools, the three game experiments were all conducted within a single day so that participants could not coordinate strategies based on information from prior participants. For the two exceptions, games were implemented on two consecutive days, and participants were recruited from different homerooms for each game to minimize the opportunity for collusion and priming. The final sample sizes were 79 pairs for UG, 75 pairs for DG and 73 trios for 3PPG. No individual participated in more than one role in one game.

BOX 3 Individual Prosociality Questions: participants can answer these questions in a five-point Likert Scale (1= not at all to 5=always).

1. “I think it is important to help other people.”
2. “I resolve conflicts without anyone getting hurt.”
3. “I tell the truth even when it is not easy.”
4. “I am helping to make my community a better place.”
5. “I am trying to help solve social problems.”
6. “I am developing respect for other people.”
7. “I am sensitive to the needs and feelings of others.”
8. “I am serving others in my community”

4.3. Methods

Game instructions and procedures follow Henrich et al. (2005, 2006). The only significant difference between Henrich et al. (2005, 2006) and the methods employed for this research is that we used the *specific offer* method instead of *maximum acceptable offer* method (sometimes called *strategy* method). For example, in UG using the maximum acceptable offer method, respondents would state their maximum acceptable offer before the offers from proposer is known to them. Any offer below the stated maximum would be rejected. On the other hand, under the specific offer method, respondents decide after an offer is made. We chose to use the specific offer method because of a concern that the maximum acceptable offer method tends to strengthen fairness considerations (Güth and Tietz, 1990)[4]. Asking individuals about future actions in a hypothetical situation may differ from actual behavior when faced with a real reward.

The "show-up fee" was 4,000 *won* (equivalent to $4 USD in 2012). Participants could earn the "show up" fee even if they decided to discontinue participation in the middle of the game or fail to pass a pre-game comprehension test. The endowment for the proposer or dictator was 8,000 *won*. The endowment for the 3rd party was 4,000 *won*. During the UG and DG experiments, any amount could be offered in 100 *won* increments. The 3PPG offer sizes were similar, but the 3rd party could only spend 1,000 *won* to punish the proposer. The 8,000 *won* of expected earnings from the game was equivalent to two hours of wage labor (minimum wage: 4,860 *won* per hour in 2012) for Korean high school students.

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[4] In addition, Falk, Fehr and Fischbacher (2005) report that the intensity of punishment toward defectors by cooperators tends to be more severe for the specific offer method than for the strategy method. However, there is contrary evidence that neither method elicits different behaviors in sequential DGs (Cason and Mui, 1998) and Chicken and Prisoner's Dilemma games (Brandts and Charness, 2000).

English game instructions were translated into Korean and then back-translated to English and then compared to the original to prevent ambiguity or errors. Game participation was voluntary. The Human Subject Division of University of Washington approved assent procedure for the adolescents and waived the need for parental permission (#38874).

One of us (J.K.) administered all the games, with some logistic assistance from teachers in recruiting students. Prior to the games, procedures were explained to the entire group of prospective players in a computer lab. Specific examples were illustrated on a chalk board. During and after these explanations, participants were encouraged to ask questions. A pre-game test was given to each participant to ensure they understood the game. Participants, at a minimum, need to understand how decisions in each role would affect their final payoff. During the pre-game test, each participant worked through a couple of game scenarios with the aim of deducing the payouts. If they found the correct earnings for each player from two scenarios, they were allowed to participate in a game. If not, they were given more examples. If they failed in these additional trials, they were paid the "show up" fee but were excluded from playing the games. Only one student was excluded for a failure to understand the game. Participants were asked to keep quiet during the test and game (but not during the instructional period). The entire procedure, from the instruction through the games, took about 50 minutes.

At the end of the game, as a form of exit survey, game participants were asked about real-life situations that resemble the game setting. This information was used to interpret game result, since expression of "moralistic" preference can differ by social domains (Henrich and Henrich 2007; Gurven and Winking 2008).

The experimental game software z-tree (Fischbacher 2007) was used to administer games in the computer lab. All experimental games were implemented with anonymous players. That is, participants were in the same computer lab, and may have known each other, but each player did not know the identity of the other participant or participants in her game. For example, suppose that fifteen players were participating in 3PPG games. The experimenter randomly matched 5 trios (random matching was done by the z-tree software). Each participant knew they are playing with someone in the same room, but only the experimenter knew who was playing with whom. Because of a common lab setting, we cannot exclude the possibility that some participants used indirect cues to narrow possible partners.

Experimental game results for individuals were merged with their survey (see Box 3) that included information on sex, income, parent's education, measures of individual prosociality, measures of social support, measures of neighborhood quality and up to seven friendship nominations. The survey is a modified version of the survey used in Wilson et al.'s (2009) study from the Binghamton Neighborhood Project. Individual prosociality questions (8 questions) measured a respondent's willingness to maintain a cooperative relationship with other people (e.g. "I am helping to make my community a better place."). Social support questions (31 questions) ascertained perceptions of social support from immediate neighbors (e.g. "I have good neighbors who help me succeed."), and are subdivided into seven categories that include family, school, religion, friends, extracurricular activities, neighborhood and general. Answers were given on a five-level Likert scale (1=not at all to 5=always). We explored whether any of these variable predict offer size in three games at the individual level. We also investigated variation in game behavior at the neighborhood and school level.

4.4. Results

The UG results are given in Table 10 and Figure 8. These results are generally consistent with other studies in developed countries (Camerer 2003). The mean (40.8% of stake) and median (41.3%) offer sizes, frequency of rejection for low offers (less than 20% of the stake) are typical. The lack of a significant sex difference is also consistent with other studies (female (N=35, $\bar{x} = 3397.1, \sigma = 1149.8$) vs. male ($N$=44, $\bar{x} = 3156.8, \sigma = 1032.6$)). In addition, there are few offers in the category of 0%-10% (0 out of 79) and the hyper-fair category 51%-100% (8 out of 79). However, some peculiarities are also found. For example, the rejection rate for fair offers (41%-50% of endowment) is rather high (12.1%, 4 out of 33). Although the modal offer of 50% is consistent with other studies, the percentage of modal offers (22.8%) is relatively low.

Table 10. Ultimatum game results summary

No. of Pairs	Mean[1]	Median[1]	Mode[1] (% of sample)	Percentage Female	Rejections	Low Rejections[2]
79	0.408	0.413	0.5 (22.8%)	44.3%	16.5%	2 out of 4 (50%)

[1] Percentage of endowment.

[2] Frequency of rejections for offers less than or equal to 20%.

The *income maximizing offer* (IMO) refers to the amount of offer that maximizes proposer's expected utility assuming she knows the rejection distribution of the population beforehand (McElreath and Camerer, 2004). Assuming no risk aversion, an IMO of 23.75% is significantly lower than the observed mean offer (40.8%)

The DG results are given in Table 11 and Figure 8. These results are also within the range of other studies conducted in developed countries (Camerer, 2003). Positive mean (17%) and median (13%) offers suggest that some portion of proposers playing the UG were genuinely other-regarding. As observed in other studies, no significant sex difference was found, although males tended to be more generous than females (female (*N*=22, $\bar{x} = 909.6, \sigma = 1047$) vs. male (*N*=52, $\bar{x} = 1413.5, \sigma = 1512.2$)).

Table 11. Dictator game results summary

No. of Pairs	Mean[1]	Median[1]	Mode[1] (% of sample)	Percentage Female
75	0.17	0.13	0 (31%)	29.3%

[1] Percentage of endowment.

The 3PPG results are given in Table 12 and Figure 8. Considering the presence of a third party punisher, it is striking that there is almost no difference found between the DG and 3PPG results. It is even more surprising considering the high frequency of punishment for low offers

(45.8%). The punishment by the 3rd party in 3PPG was more frequent, if not severe, than the rejection by the 2nd party in the UG[5]. Assuming no risk aversion, IMO for this sample is 15% of the endowment which is approximately similar to the average offer (17.8%). In other words, the proposers in this sample were maximizing their income — that is, their average offers were consistent with expected payoff maximization for risk-neutral individuals.

Table 12. Third Party Punishment game results summary

No. of Triads	Mean[1]	Median[1]	Mode[1] (% of sample)	Percentage Female[2]	Punishment	Low Punishment[3]
73	0.178	0.1	0 (54.7%)	56.2%	35.6%	22 out of 48 (45.8%)

[1] Percentage of endowment.

[2] Percentage female proposers

[3] Frequency of punishment for offers less than or equal to 20%.

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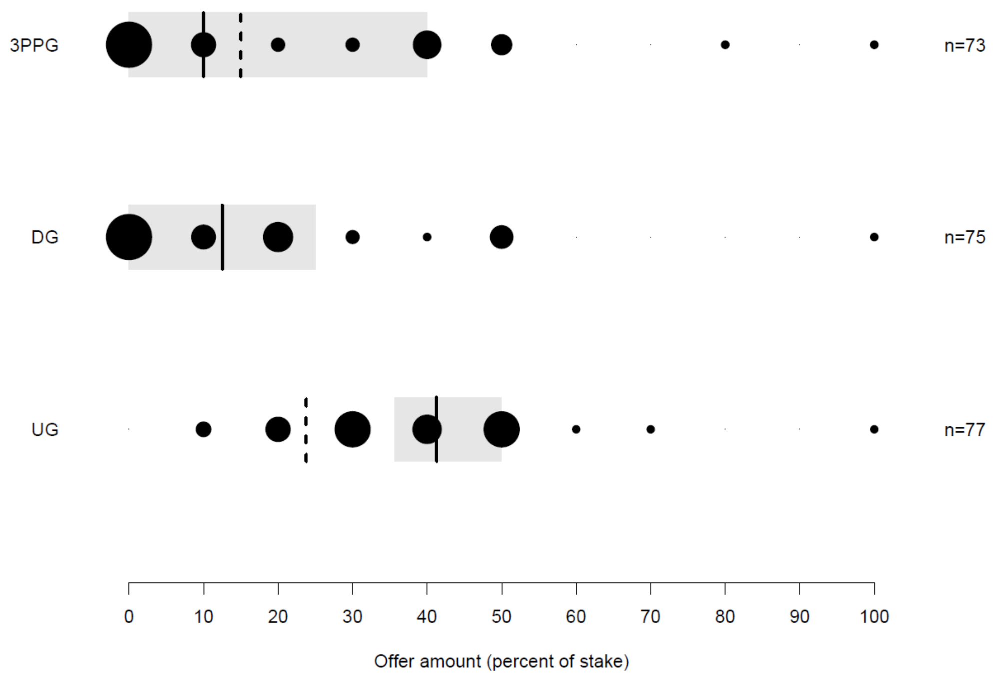
[5] We cannot compare the severity of punishment between UG and 3PPG because, 1) The 3rd party has only two options, either spend 1,000 *won* to deduct 3,000 *won* from dictator or to spend nothing, whereas respondent can reject any offer and, 2) even if the 3rd party has variety of options to punish, deduction of some amount from the proposer's payoff make the comparison difficult.

Figure 8. Distributions of offer sizes in the ultimatum, dictator and third party punishment games. The size of black bubbles represents the fraction of proposers that made a particular offer amount. The right and left edge of the lightly shaded gray bar corresponds to lower and upper quartile, respectively. The black line within gray bar gives the median offer. The dashed line gives the income maximizing offer (IMO, McElreath and Camerer, 2004). Note that while median offer is significantly greater than IMO in UG, median is slightly less than IMO in 3PPG.



4.4.1. Postgame debriefing

Following tradition in economic game experiments, the game script avoided explicit contextualizing cues or framing (i.e. descriptions as a competitive, cooperative or recreational endeavor) so that participants were free to form their own interpretation of the game. After each game was completed, we asked some participants to remain in lab without telling anyone the reason why. Participants who stayed for the optional debriefing were largely those who rejected an offer in the UG or 3PPG in order to punish the proposer. When asked for their reasons for rejection, the most common answers expressed anger at the proposer's greed and a desire to sanction unfair behavior. For example, one participant said "considering we all spent the same time and effort, the imbalance in payouts is unpleasant."

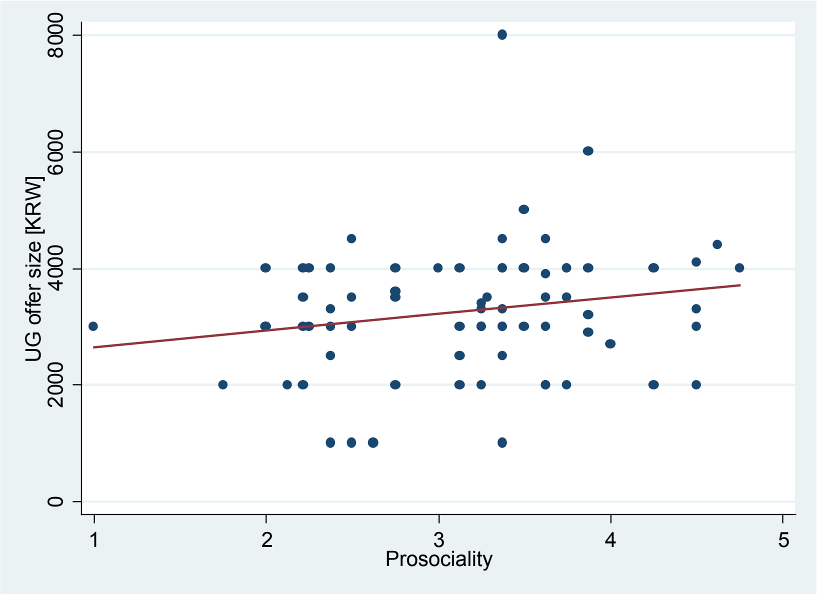
4.4.2. External Validity of the games: Individual level

To access whether any demographic and behavioral variables can predict individual offer size in the three games, we conducted multivariate linear regression analyses using sex, household income, parent's level of education, individual prosociality, number of friends (from the friendship network) and social support as predictors. The multivariate regression found only a few variables that significantly predicted offer size in each game. The significant predictors differed by game.

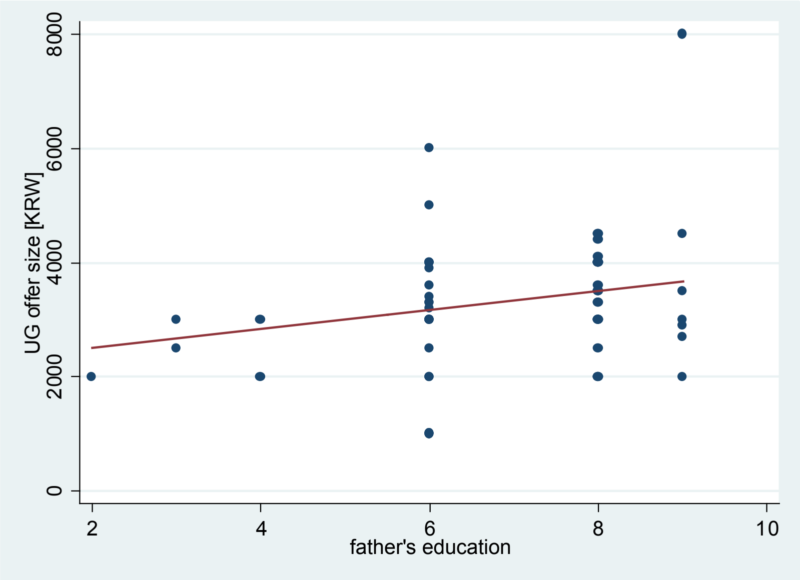
UG: When all independent variables are present (N=45), covariates did not significantly predict the offer size in UGs. With father's education (range: 2 to 9) and individual prosociality (range: 1 to 5) alone in the model (N=75), the individual prosociality is marginally significant ($\beta_{Prosociality} = 278.66$, p =.075) and father's education is significant ($\beta_{Father's\ education} = 166.48$, p =.043). In other words, participants with higher prosociality and higher father's education tended to make higher offers in the UG (see Figure 9).

Figure 9. Scatter plot with fitted line: a) individual prosociality vs. UG offer size. b) father's education vs. UG offer size

a)

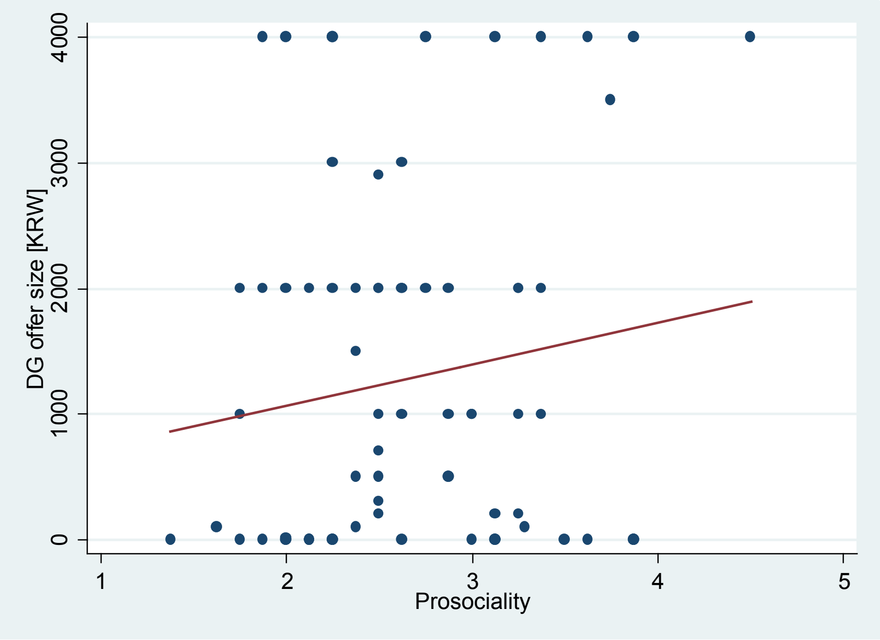


b)



The logistic regression of respondent's offer rejection in the UG (*N*=59) revealed three variables as either significant or marginally significant in the full model: the offer made by proposer ($\beta_{Offer} = -0.0018$, $p = .02$), income ($\beta_{Income} = 0.672$, $p = .078$) and prosociality ($\beta_{Prosociality} = -2.484$, $p = .03$). When only three variables are present in the model, only prosociality and offer size were significant ($\beta_{Prosociality} = -1.609$, $p = .045$; $\beta_{Offer\ size} = -0.0012$, $p = .032$). Although the effect of offer size is in the expected direction (i.e. higher offer is less likely to be rejected), the effect of prosociality is not (i.e. prosocial individuals are more likely to accept offers, holding offer size constant).

Figure 10. Scatter plot with fitted line: individual prosociality vs. DG offer size.



DG: In the DG, when all predictors are included in an ordinal linear regression (*N*=58), sex (β_{Sex} = 1127.6, *p* =.013) and individual prosociality ($\beta_{Prosociality}$ = 931.3, *p* =.007) predict DG offer size. When only sex and prosocialiy are present in the model (*N*=75), both are still significant (β_{Sex} = 846.9, *p* =.036; $\beta_{Prosociality}$ =703.1, *p* =.015). In other words, males tended to make higher DG offers than females and the more prosocial a participant is, the higher the offer (see Figure 10). Note that compared to UG models, the coefficient of prosociality is higher in DG models.

3PPG: In predicting 3PPG offer size, the full model (*N*=59) finds household income as marginally significant ($\beta_{Household\ income}$ = -198.74, *p* =.099). A stepwise regression results in household income covariate being removed from the most parsimonious model.

On the third party side of 3PPG, the full logistic model for predicting punishment (*N*=52) results in only the offer size as significant (β_{Offer} = -0.00056, *p* =.017). When the model is reduced to offer size only, the coefficient is still in the expected direction (β_{Offer} = -0.000494, *p* =.015) (i.e. stingy offers by proposers tend to be punished by third parties).

Since participants' perception of the game can considerably affect game behavior, we analyzed participant's answers to the exit survey question, "have you experienced a similar real-life situation so far?" Three categories emerged:

1) Those who perceive the game as dividing a common resource with other social partners (i.e. friends and siblings)

2) Those who viewed the game as a competition or a pastime game.

3) Those who did not provide answers. We suspect participants in this category either did not have a frame or could not express their frame verbally at the time.

From individuals in the first category, we expected a strong effect of prosociality.

1) In predicting an UG offer, the only significant variable was prosociality ($N = 19$, $\beta_{Prosocial} = 444.42$, $p= 0.034$). Note that the magnitude of coefficient is greater than the previous model that includes all participants ($\beta_{Prosocial} = 278.66$).

2) In predicting DG and 3PPG offers in the subsample, none of the variables was significant.

4.4.3. External Validity of the games: Village level

This analysis examines between-village variability and its predictors using information about the neighborhoods in which individuals reside. Since sample sizes for some neighborhood were too small, we grouped thirty administrative areas into three categories of neighborhood based on a neighborhood quality variable. Neighborhood quality was calculated by averaging individuals' assessments of social support within the same neighborhood. After excluding eleven neighborhoods with less than ten survey participants, the range of neighborhood quality was from 2.84 to 3.125. The cutoff points were made at 2.96 and 3.03 which means, for example, the average of individual prosociality within the "high" quality neighborhood is greater than or equal to 3.03. The number of neighborhoods for each category is 7, 9 and 3 for "low", "intermediate", and "high" neighborhoods, respectively.

We compared average offer size for the three types of neighborhood. Average offer sizes among neighborhood were in the expected direction only in the 3PPG. The average offer size in “high” quality neighborhoods was greater than “intermediate” neighborhoods, followed by “low” neighborhoods. However, the *t*-tests of offer size between any two neighborhoods in the three games were not statistically significant.

Lastly, to test whether the preference for costly punishment is associated with neighborhood quality, we conducted logistic regression using the neighborhood quality variable and offer size (as a control) on the probability of punishment by the third party. The neighborhood quality variable did not predict the probability of punishment.

4.5. Discussion

At the macrosocial level, the overall game results reflect underlying cultural values about acceptable behaviors and deviations subject to possible punishment, as exemplified by Henrich et al. (2005, 2006, 2010). Generous offers in UGs can come about because proposers are fair-minded or because they are afraid of direct retaliation. In DGs, the possibility of the latter is removed. These game results indicated that some of the generosity shown in UGs is ‘pure’ altruism rather than strategic considerations (i.e. intent to avoid rejection).

The low median and average offers in the 3PPG compared to UGs suggest that personal anger toward the proposer is perceived as a more powerful force than any injustice committed toward a third party. Two other studies that examined the relative strengths of second- and third-party sanctions also found stronger punishment by second parties (Henrich et al., 2006; Fehr and

Fischbacher, 2004). However, that almost no difference in offer size was found between DGs and 3PPGs is puzzling. Two interpretations are possible: Proposers in 3PPGs either did not care about third party punishment or did not consider the presence of a third party as a credible threat. Or, they behaved in an income-maximizing way. The latter interpretation is untenable because 1) the average offer size in the UG was significantly greater than the income maximizing offer, and 2) if punishment occurs, the proposer would lose 3,000 *won* which is 37.5% of stake.

Why, then, would a proposer not care about the third party? We can only provide a *post hoc* explanation. Considering the highly competitive environment Korean high school students are in, they may be less responsive to or less realistic about the presence of a third party than the game participants in Henrich et al. (2006). School life and even family life of most Korean high school students is intensely focused on college entrance exams. In recent years, about 77% of students have taken part in extra-curricular education, such as private tutoring, to prepare for the entrance exams. This private education now makes up 3% to 4% of GDP (Korean Statistics, 2011). Adolescence (ages 15-19) suicide rate (8.9 individuals per 10 million) is relatively high among developed countries, and suicide is the primary cause of death among Korean adolescences. Additional research is needed to confirm if this environment of excessive competition explains the outcome found in the 3PPG.

At the individual level, evidence about the relationship between game and non-game behavior is mixed. We found that self-reported prosociality can predict UG and DG behavior but not behavior in the 3PPG: prosocial individuals tended to give higher offers in the UG and the DG, and were less likely to reject low offers in the UG. There is some evidence that game behavior is a good predictor for real behaviors at the individual level (Bowles and Gintis 2011, pp. 39-40). In contrast, Hill and Gurven (2004) and Gurven and Winking (2008) found among the Ache and Tsimane no significant relationship between offer sizes in UG, 3PPG, DG and public goods games and prosociality measures such as labor contribution to public projects, the number of social partners, communal drinking, contributions to village feasts, and sharing food with individuals outside one's nuclear family. Interestingly, almost no rejection in UGs can be interpreted in the cultural context of the Ache: their dominant mode of social punishment is gossip rather than direct confrontation (Hill and Gurven 2004). For the Ache, expressing anger or disappointment in public is considered poor manners. Thus, for the Ache, we have a decent *post hoc* explanation at the group level but not at the individual level. In the same vein, it is perplexing that when we limited our analysis to individuals who framed the game as dividing a common resource with a partner it did not result in a significant association between prosociality and offer size in the DG and 3PPG. It may be that people in this framing category were actually heterogeneous in their perceptions of the game.

The lack of association between a neighborhood quality measure and between-village variation is puzzling but the result is consistent with the cross-cultural study of Henrich et al. (2005) who were also unable to find covariates that explain variation within an ethnic group. Recently, Lamba and Mace (2011) found some demographic factors (such as age, social network size and village population size) that explain some between-village variation in a public goods game and a naturalistic measure of behavior involving the distribution of salt, an essential and locally valued resource (the "common-pool resources" format of public goods game), in central India. In addition, they found the amount of between-village variation (18.2%) in salt deviation is comparable to the amount of cross-cultural variation (12%) in the UG in Henrich et al. (2005). However, their salt deviation experiment has a methodological flaw. In the standard common-pool format of a public goods game, each individual can take a limited amount and what remains in the common pool is divided equally among participants regardless of their withdrawal amount. However, in the salt deviation experiment, since individuals could take any amount from a common pool of salt, those in a late round might behave differently from those in an earlier round. In other words, those in a late round should make decision about a *smaller* amount of salt. Considering this flaw, the small between-village variability of contributions in the public goods game (4.1%) seems realistic.

4.5.1. Framing effect of the experimental game

The possibility of bias in our results arises because the experimental setting could not ensure complete anonymity. Most of participants had some friends in the same room. In some schools, all game participants came from the same homeroom. Some participants may have considered the composition of other participants and made a decision based on a consideration of possible future interactions. However, ensuring complete anonymity for high school participants is almost impossible.

Evidence is mixed about whether group membership affects game behavior (Paciotti and Hadley, 2003). For example, when a discussion is permitted, randomly assigned group membership can affect game result (Dawes, van de Kragt, and Orbell, 1988). However, Johannesson and Persson (2000) found no differences in DG allocation whether the recipient group is composed of other students or members of the general population.

4.5.2. Effect of Age

Our understanding of the developmental trajectories of learning fairness is still incomplete. In part, this is because experimental games have been rarely conducted among adolescents. It is uncertain when an adult plateau of full-blown prosociality is reached. Young children (3 to 6 years old) tend to be self-interested and as they grow older, they become more egalitarian (Camerer 2003). Their egalitarian offers seem motivated by fairness rather than an inclination to increase the earnings of the other player (Fehr, Bernhard, and Rockenbach, 2008). In UGs using M&M candies or money, kindergartners accepted low offers about 70 percent of time, compared to about 40 percent for third- and sixth-graders (Murnighan and Saxon, 1994). In UGs and DGs conducted among second, fourth, fifth, ninth and twelfth grades, offer sizes in both games increase by age, with the most significant increase occurring from second to fourth or fifth grade (Harbaugh, Krause, and Liday, 2000).

In addition, the onset of egalitarianism seems to differ between anonymous and public settings. Using games with a simple payoff structure for three age categories (3-4, 5-6, and 7-8 years old) in anonymous settings, Fehr, Bernhard, and Rockenbach (2008) demonstrated other-regarding preferences significantly emerging at 7 to 8 years of age. However, using the same games but in non-anonymous setting, House et al. (2012) has found a weak age-related change in prosocial behavior (most children were prosocial).

Considering all studies of the developmental trajectory, significant change seems to occur by age 13 years. Thus, we tentatively assume the results presented here for 16 to 17 year-old high school students is generalizable to the Korean adult population in Pohang.

4.6. Conclusions

This study provides empirical evidence for the external validity of UGs and DGs at the individual level. However, we did not find covariates that explained 3PPG behavior at the individual level. Furthermore, covariates could not explain behavior in all three games at the village level. This inconsistency suggests that further research is needed on the external validity of these games in a variety of social settings.

Chapter5: Conclusion

5.1. Summary of findings

This dissertation project is an attempt to describe the relationship between population structure and large-scale cooperation *and* to explore the factors that are responsible for preferences for helping others in adolescence. The lens I am looking through at these phenomena is a combination of multilevel selection theory and gene-culture coevolutionary theory. Most importantly, I wanted to address three issues. First, I wanted to develop a method to assess whether a necessary condition for the evolution of altruism, preferential interaction, exists. And then apply it in a neighborhood-structured population (2nd chapter). Second, I wanted to evaluate the correspondence between individual and group perspectives when groups are conceived as the means by which an individual character (e.g. altruism) might increase its frequency relative to the alternatives (MLS1).(3rd chapter). Third, while economic games are generally regarded as tools to measure the cooperativeness at the group level, I wanted to explore whether these same tools could explain within-group variation in prosociality.

I chose high school students as a target population because (1) they may be a litmus test of societal well-being of specific neighborhoods, (2) on a city-wide scale, it is easier to conduct a research on samples of high school students than on samples of adults, and (3) because high school students usually stay in neighborhoods similar to those in which they were born.

In the second chapter, I argued that preferential interaction is one of necessary conditions for the evolution of prosociality. The requirement for preferential interaction holds regardless whether a meta-population is subdivided into distinct and isolated subgroups or has ephemeral boundaries with a high migration rate (Bowles and Gintis, 2011). I developed a new tool, based on social network analyses, for the measurement of assortment. Specifically, preferential interaction can be said to exist when the number of ties between prosocial individuals is more numerous than the ties between prosocial and non-prosocial individuals *and* the ties between non-prosocial individuals. The ERGM results revealed a significant level of assortment: prosocial individuals are favored as friends by population overall, especially by other prosocial individuals.

In the third chapter, the correspondence between individual and group perspectives, was explored. The causes for proliferation of altruism can be described correctly in both perspectives (pluralism) (Dugatkin and Reeve 1994; Sterelny 1996; Kerr and Godfrey-Smith 2002; Okasha 2006). While hierarchical analysis suggests higher quality neighborhoods tended to be composed of more prosocial individuals, the high quality neighborhood did not show more popularity of ties between prosocial individuals in the friendship network. In addition, multivariate and hierarchical analyses of individual prosociality revealed that multiple sources of social support and place of residence may determine individual preference for helping others.

In the fourth chapter, the external validity of three economic games (the ultimatum, dictator and third party punishment games) was examined. At the group level, the significantly larger than income maximizing offer size in the ultimatum games *and* the significantly positive median offer size in the dictator game indicate that the population as a whole contains a substantial number of cooperative individuals. However, the similar level of median offer sizes in the dictator and third party punishment games is perplexing. Presumably, the similarity in offer sizes under two very different conditions, is because proposers did not regard the presence of a third party as a credible threat. At individual level, individual prosociality predicted game behavior in the ultimatum and dictator games, but not in the third party punishment game. However, none of covariates predicted game behavior at the village level.

5.2. Shortcomings

Some of the shortcomings of the research program were inevitable because of a relatively short duration for the field research (~ 3 months) and limitations inherent in each of the research methods.

First, the survey data was self-reported, and may suffer from the types of biases that come with self-reports. Some of this bias could be minimized by asking questions about actual behavior such as recall of past volunteering behaviors. In addition, the act of filling out the survey may be a prosocial act, therefore selecting for more prosocial individuals.

Second, although individual prosociality scores are buttressed by ultimatum and dictator game result (but not by third party punishment game), external measures of neighborhood quality are scarce in this study. Here the only non-survey measure of neighborhood quality is voter turnout. Ideally, other types of externally assessed neighborhood quality measures such as crime rate, recycling rate, and the level of participation in community activities could have been collected and incorporated into the analyses.

Third, a more refined measure of preferential interaction may be developed. Using the ERGM method in Chapter 2, it would be possible to compare the effect of preferential interaction and the effect of sex homophily on the configuration of *a* friendship network. However, it would be impossible to compare the levels of assortment between *two* friendship networks since the parameter sizes in two network are affected by various factors. Further, if the ERGM analysis of either network fails to converge, the level of assortment cannot be computed.

Fourth, instead of using a neutral script in the economic games, explicit contextualizing scripts might be better at making measures of prosociality more uniform, since the costs and benefits of a specific action might differ across social domains (Gurven and Winking 2008). If interpretations of the neutral script differ across game participants, measures of prosociality include the variation of *interpretation* in addition to the cooperativeness of individuals. For example, in each economic game, the context might be framed as a friendship-related transaction.

Lastly, the qualitative components of this research are relatively weaker than quantitative side. A common feature of much high-quality research in biocultural anthropology is the use of complementary qualitative and quantitative methods. The use of a qualitative approach could be used to explore things like why students in the school of higher average scores in college entrance exams tended to be more prosocial. Further, a well designed exit interview for the economic games may provide a better understanding of why proposers in third party punishment game did not regard the presence of third party as a credible threat.

5.3. Future direction

Future directions for this project might include conducting similar studies in different regions in Korea. Additonally, the approaches I have used could be conducted cross-culturally, where a higher level of between-neighborhood variation could be expected. The friendship network method can be used to test theoretical ideas from other types of survey data (e.g. Add Health data) or other types of outcomes---like behavioral observations on food-sharing in a hunter-gatherer setting.

This work has tried to empirically test some of the theoretical developments in multilevel selection and cultural group selection. One potential contribution inspired by the present research would be a diachronic approach to cultural group selection. I explain this in the next section.

5.4. Diachronic approach to cultural group selection

As a concluding remark, I want to point out an important aspect of studying human behavioral adaptation. In the current major transition literature, a key inquiry has shifted from a ‘synchronic’ to a ‘diachronic’ formulation of the levels of selection question (Okasha, 2005; Griesemer, 2000). In a synchronic approach, a nested hierarchy is treated as a taken-for-granted exogenous fact. However, according to the newer diachronic approach, a nested hierarchy itself is a *product* of multilevel selection. Multicellular organisms did not exist at one time. Rather, they had evolved from interactions among eukaryotic microorganisms.

Similarly, there is a tendency to think of our nature as a product of past natural selection rather than as continuously evolving. Sam Bowles and colleague's parochial altruism is an example (Bowles, 2006, 2008, 2009; Choi and Bowles 2007; Bowles and Gintis 2011). Parochial altruism posits that our prosocial motives have evolved through hostility toward members of other groups. So they assume primitive societies were characterized by inter-group violence, with frequent warfare waged among such groups. Their argument probably reflects some grain of truth but we need to ask about some initial state when in-group favoritism and ethnic markers had not yet developed. Less work has done about conditions that make cooperation potentially profitable in the first place. Moreover, compared to other organism with high levels of social cooperation, such as eusocial insects, human groups lack cohesive and other individual-like features. Humans may be on the way toward group selected organisms through reliance on social institution, division of labor and cultural norm.

One of the triggers for group-selected organisms may be a human feature that both sexes may emigrate or remain philopatric while many other primates are characterized by either male dispersal or female dispersal, but not both (Hill et al. 2011). This flexible philopatric residence pattern during human evolution has resulted in a widespread pattern of social groups in which the majority of individuals within the groups are unrelated. The emergence of non-kin based human social structure might result in an increased reliance in social networks. And that, in turn, may provide the context for an increase in large-scale cooperation.

I believe the more important trigger is human culture. As noted by Wilson and Sober (1989), a trait that changes population structure, altering cohesive and disruptive forces in a group, can itself be favored by natural selection. Culture does this by increasing between-group variation and decreasing within-group variation. Culture also provides an avenue for low cost forms of altruism such as information sharing.

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Appendix A: Survey questions (English)

Demographic questions
Name:
Sex (Male/Female)
Age:
Address: ______ Gu (district) _______Dong/Eup/Myun ________Li __________(street or house number)
e-mail**:
** e-mail address may be used to contact you about a follow-up study, and will not be used for anything else.
Annual Income of your family: 1. Less than $25,000
2. More than $25,000 but less than $40,000
3. More than $40,000 but less than $60,000
4. More than $60,000 but less than $100,000
5. More than $100,000
6. Unable to answer
Father's education level: 1. Elementary school dropout 2. Elementary school graduate 3. Middle school dropout 4. Middle school graduate 5. High school dropout 6. High school graduate 7. College dropout 8. College graduate 5. Postgraduate
Mother's education level: 1. Elementary school dropout 2. Elementary school graduate 3. Middle school dropout 4. Middle school graduate 5. High school dropout 6. High school graduate 7. College dropout 8. College graduate 5. Postgraduate

Quality of Life
Answers to each question can be one of four scale (1=Not at all or rarely, 2=Somewhat or sometimes, 3=Often 4=Very often, 5=Almost always or always). Please give the answer that best describes your feelings.

Myself
1. "I think it is important to help other people."
2. "I resolve conflicts without anyone getting hurt."
3. "I tell the truth even when it is not easy."
4. "I am helping to make my community a better place."
5. "I am trying to help solve social problems."
6. "I am developing respect for other people."
7. "I am sensitive to the needs and feelings of others."
8. "I am serving others in my community"

Family
9. "I feel safe and secure at home"
10. "I am included in family tasks and decisions"
11. "I am spending quality time at home with my parents/guardians"
12. "I have parents/guardians who help me succeed"

13. “I have parents/guardians who urge me to do well in school”
14. “I have a family that gives love and support”
15. “I have parents/guardians who are good at talking with me about things”
16. “I have a family that knows where I am and what I am doing”

Social support: school
17. “I feel safe at school”
18. “I have a school that gives students clear rules”
19. “I have a school that enforces rules fairly”
20. “I have a school that cares about kids and encourages them”
21. “I have teachers who urge me to develop and achieve”
22. “You feel like you are part of your school.”
23. “You are happy to be at your school.”

Social Support: Friends
24. “How much do you feel that your friends care about you?”
25. “I have friends who set good examples for me”

Social support: religion
26. “I am involved in a religious group or activity”
27. “How often do you attend religious services?”

Social support: neighborhood
28. “I have a safe neighborhood”
29. “I have good neighbors who help me succeed”
30. “I have neighbors who help watch out for me”

Social support: extracurricular activities
31. “I am involved in a sport”
32. “I am involved in creative things such as music and painting”

Social support: general
33. “I feel valued and appreciated by others”
34. “I am encouraged to try things that might be good for me”
35. “I am encouraged to help others”
36. “I am given useful roles and responsibilities”
37. “I have adults who are good role models for me”
38. “I have support from adults other than my parents/guardians”

Social Network

39. For your seven closest friends, provide a full name, grade, class and the neighborhood in which he or she lives.
1) Name: _____________ Grade/class_________ Dong (neighborhood) _________________
2) Name: _____________ Grade/class_________ Dong (neighborhood) _________________
3) Name: _____________ Grade/class_________ Dong (neighborhood) _________________

4) Name: _______________ Grade/class__________ Dong (neighborhood) ____________________
5) Name: _______________ Grade/class__________ Dong (neighborhood) ____________________
6) Name: _______________ Grade/class__________ Dong (neighborhood) ____________________
7) Name: _______________ Grade/class__________ Dong (neighborhood) ____________________

Appendix B: Survey questions (Korean)

신상에 관련된 질문

이름:

학년/반:

성별 (남/여)

나이:

주소: 포항시 ____(구) _____(동/읍/면) _______(리) _________ (번지)

E-mail:

(이메일 주소는 후속 연구에 참여여부를 묻는 초대장을 보내는 용도로만 사용될 것입니다)

부모님 연간 소득 (맞벌이 부모의 경우, 소득의 총합)

1. 2500 만원 이하
2. 2500 만원 초과 4000 만원 이하
3. 4000 만원 초과 6000 만원 이하
4. 6000 만원 초과 10000 만원 이하
5. 100000 만원 초과
6. 대답할 수 없음

아버지의 교육 수준: 1. 초등 중퇴 2. 초등 졸업 3. 중학교 중퇴 4. 중학교 졸업 5. 고등학교 중퇴 6. 고등학교 졸업. 7. 대학교 중퇴 8. 대학교 졸업. 9. 대학원 졸업

어머니의 교육 수준: 1. 초등 중퇴 2. 초등 졸업 3. 중학교 중퇴 4. 중학교 졸업 5. 고등학교 중퇴 6. 고등학교 졸업. 7. 대학교 중퇴 8. 대학교 졸업. 9. 대학원 졸업

삶의 질에 대한 질문

아래에 있는 모든 문장에 대해서 본인이 얼마나 동의하는가를 답하면 됩니다. 답변은 동의의 정도에 따라 5 가지 수준으로 나뉘어 집니다. (1= 전혀 혹은 드물게, 2= 약간 혹은 때때로, 3= 자주, 4= 매우 자주, 5= 언제나 혹은 항상). 여러분이 가장 가깝게 느끼는 정도에 표기해 주세요.

나 자신에 대한 질문

1. "나는 다른 사람들을 돕는 것이 중요한 일이라고 생각한다."

2. “나는 갈등을 해결할 때 다른 사람들에게 상처를 주지 않으려 노력한다.”
3. “나는 난처한 순간에도 진실을 말하는 편이다.”
4. “나는 우리 동네가 더 나은 동네가 되도록 노력한다.”
5. “나는 주변 사람들의 문제를 해결하는데 도움을 준다.”
6. “나는 다른 사람들에게 존경심을 갖고 있다.”
7. “나는 다른 사람들의 필요와 기분을 신경 쓰는 편이다.”
8. “나는 주변의 누군가를 돕고 있다.”

가족에 대한 질문

9. “나는 집에 있을 때 편안하고 아늑하다.”
10. “가족이 어떤 일을 할 때나 무엇을 결정할 때 나의 의견도 중요하다.”
11. “나는 집에서 부모님/후견인**과 보내는 시간이 가치 있다고 생각한다.”
** (부모님을 대신하는 사람, 이를테면 이모, 고모, 큰 형, 큰 오빠 등)
12. “나의 부모님/후견인은 내가 성공하도록 도와준다.”
13. “나의 부모님/후견인은 학교생활을 잘 하도록 신경써주는 편이다.”
14. “우리 가족은 나를 사랑해주고 지지해준다.”
15. “부모님/후견인은 나와 대화가 잘 통한다.”
16. “우리 가족은 내가 어디에 있고 무엇을 하는지 알고 있다.”

학교에 대한 질문

17. “나는 학교에 있을 때 편안하다.”
18. “우리학교의 규칙은 명쾌하다.”
19. “우리학교는 학생들에게 규칙을 공평하게 부과한다.”
20. “우리학교는 학생들에게 관심을 갖고 지원한다.”
21. “우리학교 선생님들은 내가 발전하고 성취하도록 힘쓴다.”
22. “나는 나 자신이 이 학교의 구성원이라고 느낀다.”
23. “나는 이 학교에 다니는 것이 행복하다.”

친구에 대한 질문

24. “나는 친구들에게 관심을 많이 받는다고 생각한다.”
25. “나는 내 주변에 본받고 싶은 친구가 있다.”

종교에 대한 질문

26. “나는 현재 종교 집단에 속해있거나 종교 활동을 하고 있다.”
27. “얼마나 자주 종교 예배에 참여하는가?”

이웃에 대한 질문

28. “우리 동네는 안전하다.”
29. “우리 이웃은 내가 성공하도록 돕는다.”
30. “나에게 신경을 써주는 이웃이 있다.”

과외 활동에 대한 질문

31. “나는 스포츠 활동에 참여한다.”
32. “나는 음악, 미술과 같은 창의적인 활동에 참여한다.”

그 밖의 사회적인 지원에 대한 질문

33. “나를 가치 있고 귀중하게 여기는 사람들이 주변에 있다.”
34. “누군가는 나에게 유익한 일을 시도해보도록 권유한다.”
35. “누군가는 내게 타인을 도우라고 권유한다.”
36. “나는 내게 주어진 역할과 책임에 보람을 느낀다.”
37. “나는 내 주변에 본받고 싶은 어른이 있다.”
38. “부모님/후견인 이외에도 나에게 도움을 주는 어른들이 있다.”

사회적 관계망

39. 당신과 가장 가까운 친구들(7 명 까지)의 이름과 학년/반, 그 친구가 살고 있는 동네를 적어주세요 (자세한 주소는 필요 없습니다).

1) ______학년 _______반 이름: ________________ 동네: _________(동/읍/면/리)
2) ______학년 _______반 이름: ________________ 동네: _________(동/읍/면/리)
3) ______학년 _______반 이름: ________________ 동네: _________(동/읍/면/리)
4) ______학년 _______반 이름: ________________ 동네: _________(동/읍/면/리)
5) ______학년 _______반 이름: ________________ 동네: _________(동/읍/면/리)
6) ______학년 _______반 이름: ________________ 동네: _________(동/읍/면/리)

Appendix C: R codes and Goodness of fit plots for ERGMs

Here we give the R code to implement the ERGM models in the chapter 2:

Code for model 1

```
model.01 <- ergm(friendship.net ~ edges + nodematch("sex") +
   nodeicov("individual.prosociality") +
   nodeocov("individual.prosociality") +
   absdiff("individual.prosociality") + nodeicov("household.income") +
   nodeocov("household.income") + absdiff("household.income") +
   nodeicov("father.education") + nodeocov("father.education ") +
   absdiff("father.education") + odegree(0), constraints=~bd(maxout=7))
```

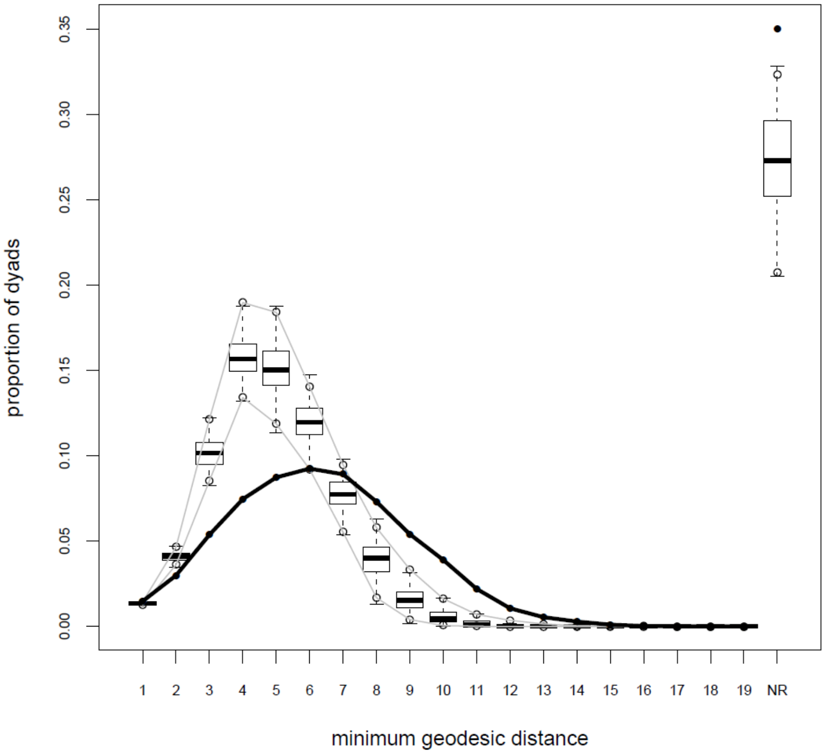
Code for model 2

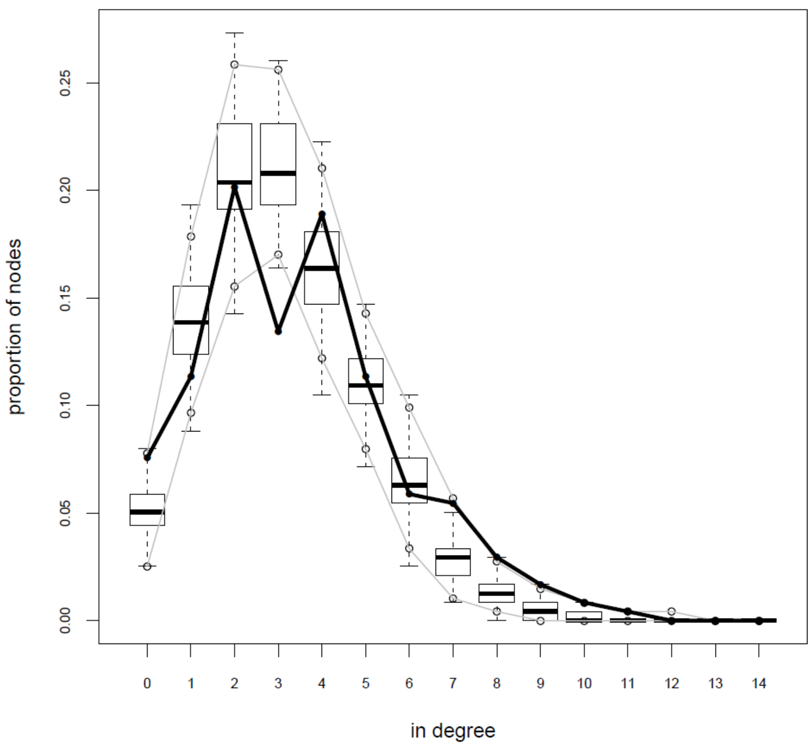
```
model.02 <- ergm(friendship.net ~ edges + nodematch("sex") +
   edgecov(prosociality.product.sqrt) +
   edgecov(household.income.product.sqrt) +
   edgecov(father.education.product.sqrt) + odegree(0),
   constraints=~bd(maxout=7))
```

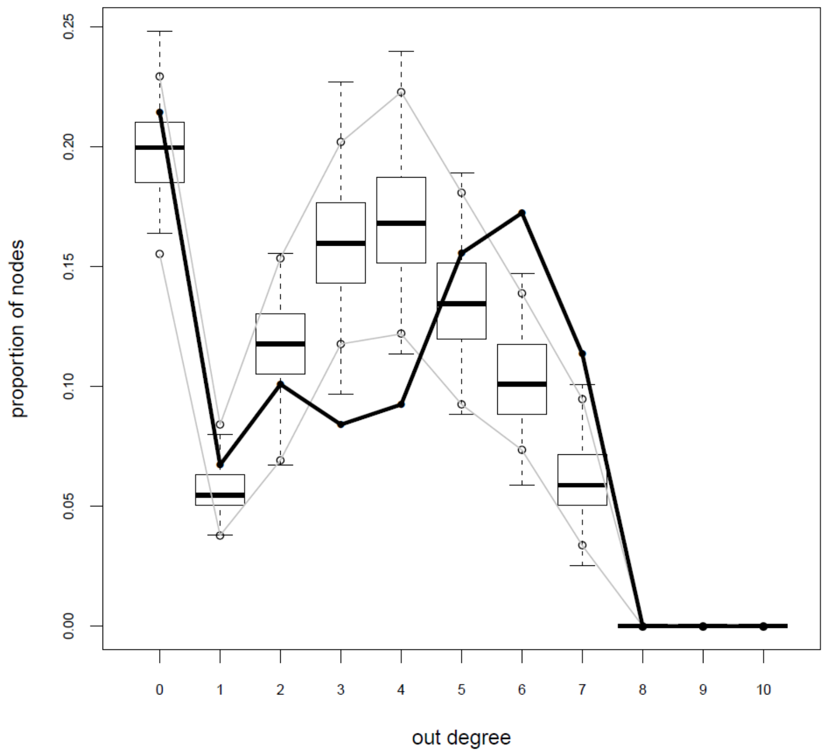
Goodness of fit plots:

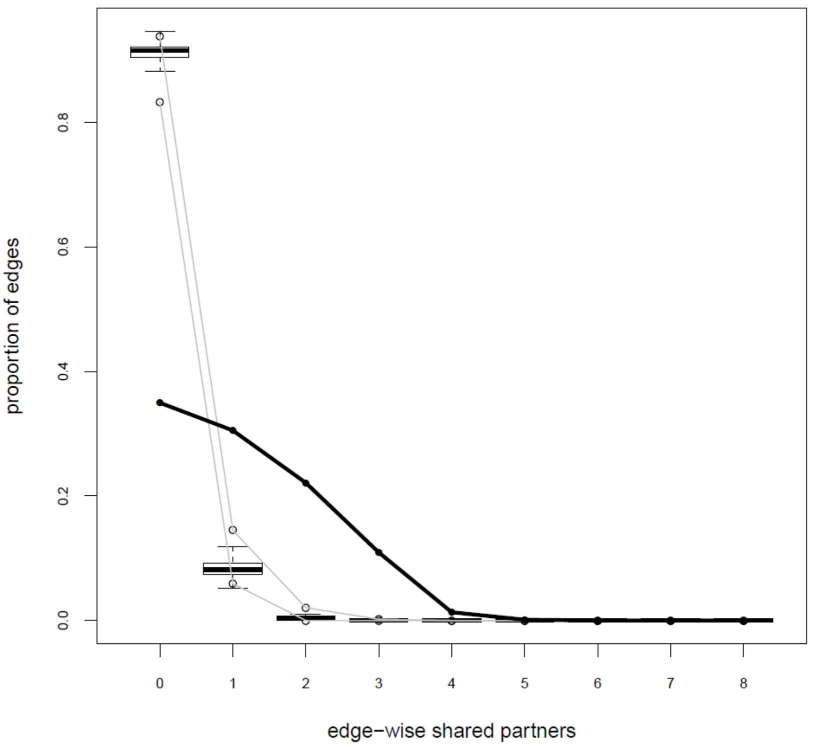
Goodness-of-fit plots compare network statistics for an observed network to those simulated from a given model. This allows for a visual or statistical comparison of the degree to which that model captures aspects of observed network structure. In these plots, the dark line represents the statistics for the observed network, and the boxplots represent the range of the same statistics over 100 simulated networks for that model. The y-axis plots the proportion of the relevant unit (nodes, edges, or dyads) possessing the value of the statistic that is listed on the x-axis. Minimum geodesic distance is the length of the shortest path between two nodes; “NR” indicates that two nodes are not reachable; i.e., there is no path of any length connecting them. In-degree and out-degree reflect the number of in-ties and out-ties a node has. Edgewise shared partners measures the count of partners that two nodes have in common, for all sets of nodes that are ties. It is equivalent to the number of triangles each edge is in; it is thus a measure of local clustering. While local effects such as in-degree and out-degree are well captured, our models could not match the geodesic distribution and the ESP distribution. However, this limitation is not a crucial one, since these higher-order aspects of network structure are not really our prime focus.

Goodness of fit plot for model 1

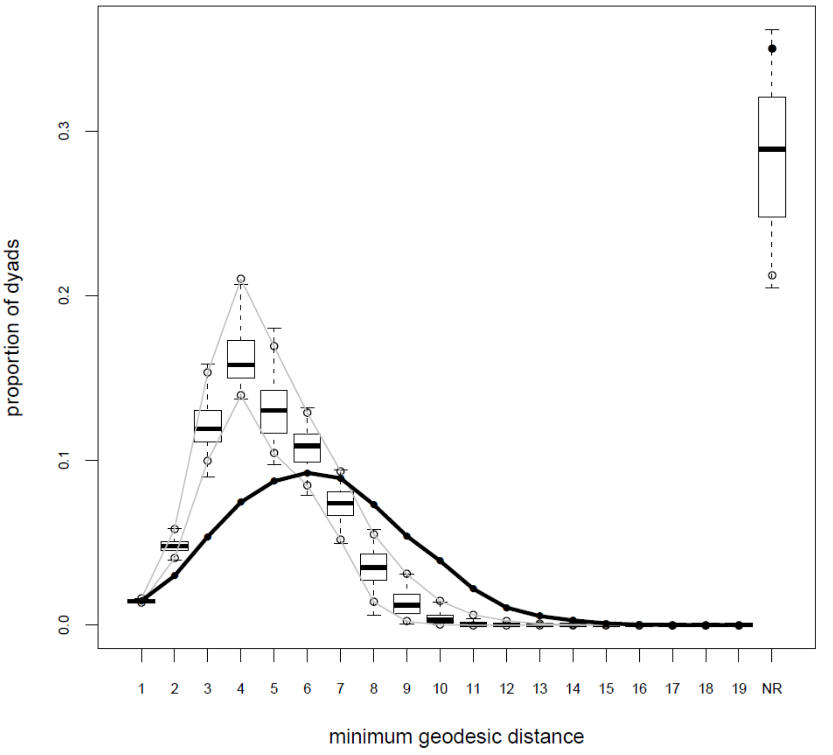


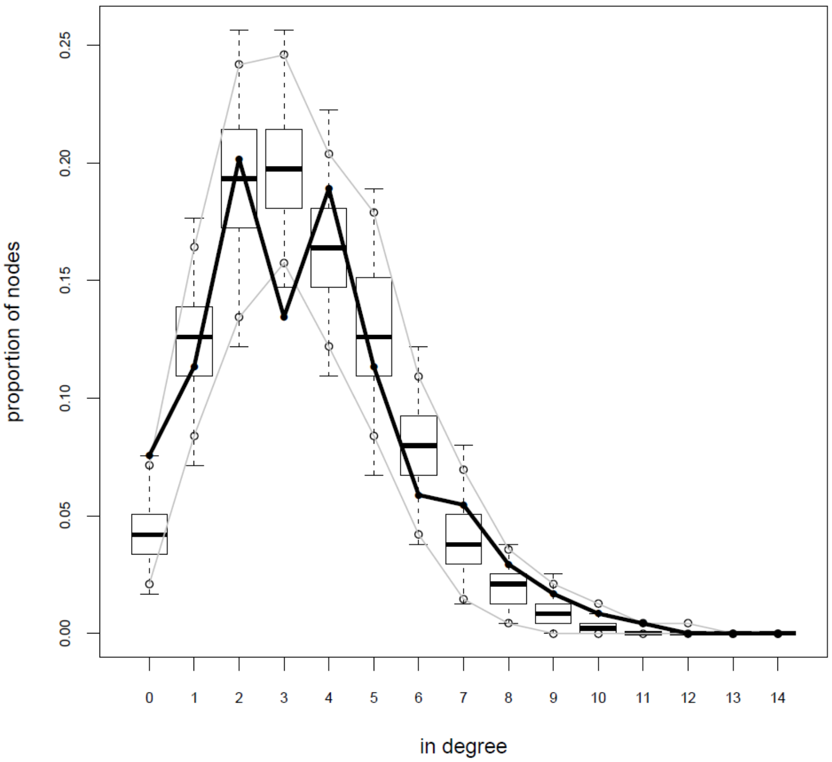

proportion of nodes
0.00
0.05
0.10
0.15
0.20
0.25
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
in degree


proportion of nodes
0.00
0.05
0.10
0.15
0.20
0.25
0
1
2
3
4
5
6
7
8
9
10
out degree



Goodness of fit plot for model 2




proportion of nodes
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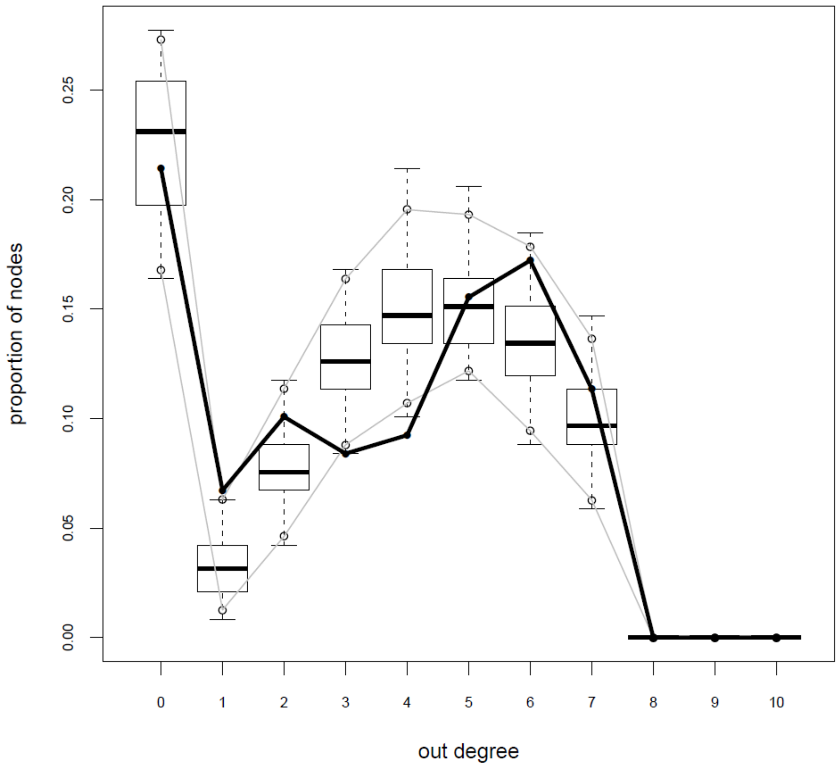
10
11
12
13
14
in degree


proportion of nodes
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0.15
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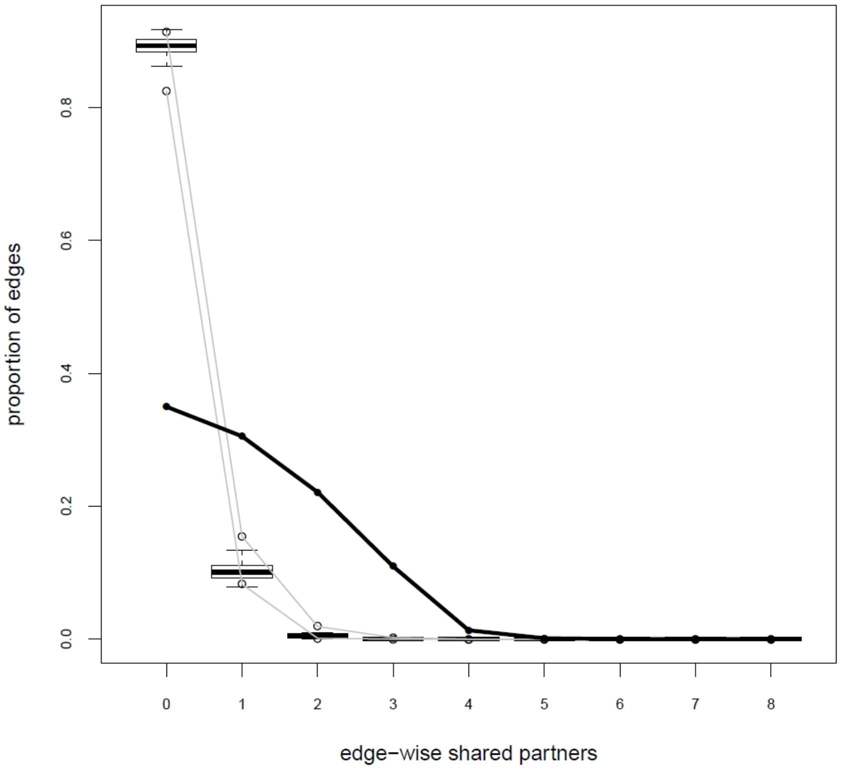
10
out degree


proportion of edges
0.0
0.2
0.4
0.6
0.8
0
1
2
3
4
5
6
7
8
edge−wise shared partners

Curriculum Vitae

JUN-HONG KIM
DEPARTMENT OF ANTHROPOLOGY
UNIVERSITY OF WASHINGTON
Box 353100 Seattle, WA 98195
zuma@uw.edu

PROFESSIONAL PREPARATION:

2013 Ph.D. Biocultural Anthropology, University of Washington, Seattle
Dissertation title: *Population Structure and Large-scale cooperation in Pohang, South Korea*

2006 M.A. Anthropology, Seoul National University, Seoul, South Korea

2003 B.S. Industrial Engineering, Seoul National University, Seoul, South Korea

RESEARCH INTERESTS:

Large-scale cooperation by cultural group selection, multilevel selection, culture-gene coevolution, levels of selection question, mathematical modeling; South Korea.

PUBLICATIONS:

Book (translation):

Not by genes Alone: How culture transformed human evolution, Peter J. Richerson and Robert Boyd, University of Chicago Press. 2005. (Translated into Korean, Published Aug 10, 2009)

Manuscript under review

Jun-Hong Kim, Darryl J. Holman and Steven Goodreau (Revised & Submitted for *Evolution and Human Behavior*) Using network methods to test preferential interaction among Korean high school students

Jun-Hong Kim and Darryl J. Holman. External Validity of Experimental games: Can game behavior explain within-group and individual variation of prosociality?

Manuscripts in preparation

Geoff Kushnick, Benjamin Chabot-Hanowell, Jun-Hong Kim, Vittorio Magnano, and Kata Oláh. Parental Investment Vignette Project: Using third-party judgments to study maternal decision-making.

Jun-Hong Kim and Darryl J. Holman. Preferential Interaction and Large-scale cooperation: the issue of pluralism.

PRESENTATIONS:

Jun-Hong Kim, Darryl J. Holman and Steven Goodreau, “Preferential Interaction and Large-scale cooperation: the issue of perspective switching.” 24th Annual Human Behavior and Evolution Society Conference, Oral Presentation, Miami Beach, FL, July 17-20, 2013.

Jun-Hong Kim, Darryl J. Holman and Steven Goodreau, "Preferential Interaction and Large-scale cooperation: the issue of perspective switching." 1st Northwest Evolution, Ecology, and Human Behavior Symposium, Boise, ID, Apr 19-21, 2013.

Geoff Kushnick, Benjamin Chabot-Hanowell, Jun-Hong Kim, Vittorio Magnano, and Kata Oláh. "Using third-party judgments to study maternal decision making." 1st Northwest Evolution, Ecology, and Human Behavior Symposium, Boise, ID, Apr 19-21, 2013.

Jun-Hong Kim, "Using network method to test preferential interaction among Korean high school students," 111th Annual Meeting of American Anthropological Association, Oral Presentation, San Francisco, CA, Nov 14-18, 2012

Jun-Hong Kim, "Preferential interactions among Korean high school students: three social network analyses," 24th Annual Human Behavior and Evolution Society Conference, Oral Presentation, Albuquerque, NM, June 13–17, 2012

Jun-Hong Kim, "Using network methods to assess prosociality in Korean and U.S. high school students," The IGERT Seminar Series (Model-Based Approaches to Biological and Cultural Evolution), University of Washington, Seattle, WA, Feb 16, 2012

Jun-Hong Kim and Darryl Holman, "Using Network Analyses to Test Hypotheses on Prosociality," Biocultural Anthropology Seminar Series, University of Washington, Seattle, WA, Nov 16, 2011

Jun-Hong Kim, "Preferential interaction among prosocial individuals: social network analysis of friendship network," 23rd Annual Human Behavior and Evolution Society Conference, Poster Presentation, Montpellier, France, June 29–July 3, 2011

Jun-Hong Kim, "Cultural Evolutionary Process of Human Cooperation on a city-wide scale," Biocultural Anthropology Seminar Series, University of Washington, Seattle, WA, Nov 10, 2010.

ACADEMIC POSITIONS:

2013, Summer	Instructor; Department of Anthropology, University of Washington, Seattle Course taught: Principles of Biocultural Anthropology (BIO A 201)
2012, Summer	Instructor; Department of Anthropology, University of Washington, Seattle Course taught: Principles of Biocultural Anthropology (BIO A 201)
2011, Summer	Instructor; Department of Anthropology, University of Washington, Seattle Course taught: Principles of Biocultural Anthropology (BIO A 201)
2010, Summer	Instructor; Department of Anthropology, University of Washington, Seattle Course taught: Evolution and Human Behavior (BIO A 100/BIOL 108)

TEACHING ASSISTANTSHIPS:

2007-present Department of Anthropology, University of Washington, Seattle
Principles of Biological Anthropology (BIO A 201: 11 quarters), Human Biological Diversity (BIO A 101: 1 quarter), Human Fossils and Evolution (BIO A 388/389: 2 quarters)

2013, Winter Department of Biostatistics, University of Washington, Seattle
Biostatistics for the Health Sciences (BIOST 310: 1 quarter)

2011, Spring School of Pharmacy, University of Washington, Seattle
Principles of Evidence-Based Medicine II: Applying and Interpreting Biostatistics in Clinical Research (PHARM 508: 1 quarter)

RESEARCH ASSISTANTSHIPS:

2004-5	A Study of North Korean Biological Standards of Living Using Anthropometric Data from North Korean Escapees, PI: Sunyoung Pak, Seoul National University. Duties: anthropometric measurement, data analysis
2006-7	Research Trainee, Mentor: Eric Alden Smith.

GRANTS & AWARD:

2013	Presentation and Training Grant ($1,000), Center for Statistics and the Social Sciences, University of Washington
2013	Conference Travel Fund ($300), Department of Anthropology, University of Washington
2011-2	NSF Doctoral Dissertation Improvement Grant. Population Structure and Large-Scale Cooperation in Pohang, South Korea. PI: Darryl J. Holman, co-PI: Jun-Hong Kim ($14,761).
2011	Korean Honor Scholarship ($1,000), Embassy of the Republic of Korea
2011	Statistical Concentration in Anthropology
2011	Presentation and Training Grant ($1,000), Center for Statistics and the Social Sciences, University of Washington
2011	Conference Travel Fund ($500), Department of Anthropology, University of Washington
2010	Department Pilot Fund ($1,040), Department of Anthropology, University of Washington
2009	Statira Biggs Scholarship ($1,500), University of Washington
2006	Recruitment Packages (3 years of RA/TAship), University of Washington

SERVICES:

2012-3	Sub-faculty Committee, Department of Anthropology, University of Washington
2012, summer	TA conference facilitator Topics: “Grading Short-Answer Questions” and “International TA panel”
2011, summer	TA conference facilitator Topics: “Presenting Information Effectively” and “International TA panel”
2010-11	Search Committee (Geneticist faculty position), Department of Anthropology, University of Washington
2010-12	Curriculum Committee, Department of Anthropology, University of Washington
2003-4	Graduate technology assistant, Department of Anthropology, Seoul National University

VOLUNTEER POSITIONS:

2007-8	President, Korean Graduate Student Association (KGSA), University of Washington
2004-5	Volunteer Mathematics & Science Instructor for North Korean refugees

Graduate Advisors (Doctoral committee):

Darryl Jon Holman (Chair)	University of Washington
Bettina Shell-Duncan	University of Washington
Steve Goodreau	University of Washington
Carl Bergstrom	University of Washington

AFFILIATION:

Human Behavior and Evolution Society
American Anthropological Association
Center for Studies in Demography and Ecology at University of Washington
Center for Statistics and the Social Sciences at University of Washington

LANGUAGES:

Native Korean; Fluent English; Stata; R; mle